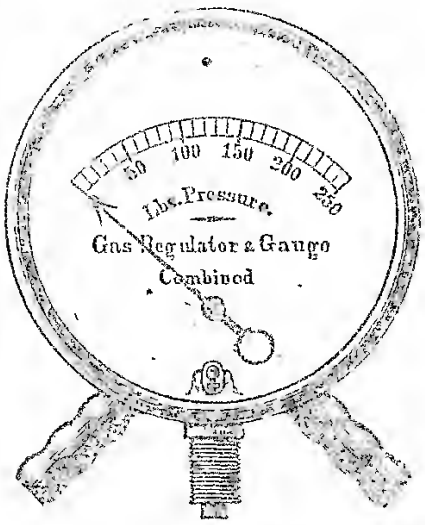
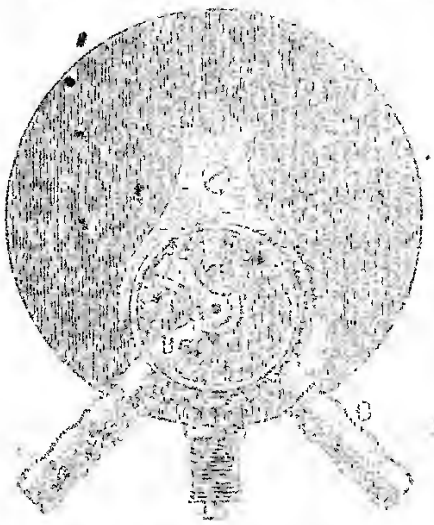
MECHANICAL DENTISTRY





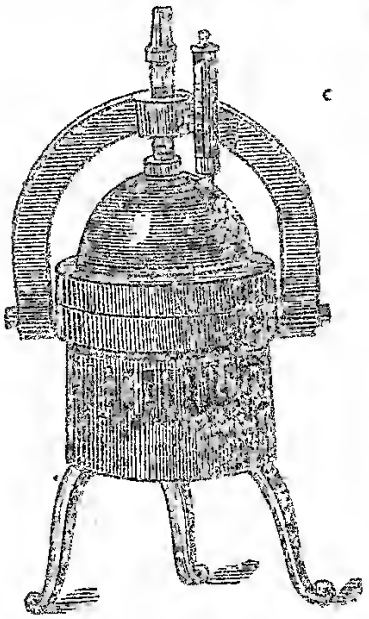
JAMIESONS'

Gas Regulator and Gauge.

This Gauge is specially made strong and is less liable to get out of order than many now made. It registers to 250 lbs. or over 400° Fahr.

Reduced Price 35s. with Syphon, can be fixed to any Vulcaniser.

BIJOU GUN METAL VULCANIZERS.



Small in compass, but large enough for large flasks. They are extra strong. Saving of time and gas ensured. They are unequalled for completeness.

One Flask size	30/-
Two ,, ...	48/-
Three ,, ...	68/-
Complete with Thermometer and Burner	37/-
Complete with Thermometer and Burner	55/-
Complete with Thermometer and Burner	75/-
Best Pin Flasks	3/-
Thermometers	5/-
Burners	2/-

W. & J. JAMIESON,

10, BROAD STREET, GOLDEN SQUARE, LONDON, W.

MECHANICAL DENTISTRY

A PRACTICAL TREATISE ON THE CONSTRUCTION OF THE VARIOUS KINDS OF

ARTIFICIAL DENTURES

COMPRISING ALSO USEFUL FORMULÆ, TABLES, AND RECEIPTS FOR GOLD PLATE, CLASPS, SOLDERS, ETC. ETC. ETC.

BY CHARLES HUNTER

FOURTH EDITION

LONDON
CROSBY LOCKWOOD AND SON
7, STATIONERS' HALL COURT, LUDGATE HILL
1895

[*All Rights reserved.*]

LONDON:
PRINTED BY J. S. VIRTUE AND CO., LIMITED,
CITY ROAD.

PREFACE.

IN introducing the present work to the notice of the dental profession, I may say that my design has been to make it a specially practical one. It is written after an experience of nearly twenty years as a mechanical dentist, and contains, besides the results of that experience, much that has been derived from the practical knowledge of others. I hope therefore that I have been enabled in the following pages to give a clear and accurate account of the actual methods adopted by competent workmen, in the construction of the various forms of artificial dentures.

At page 216 and following pages will be found formulæ, tables, and receipts, which have been carefully collected from various trustworthy

sources, and which, being of direct interest to the dentist, will, I hope, further add to the practical character of the work.

To Dr. Richardson's valuable treatise I have been indebted for the account given at page 193 of Dr. Kingsley's method of constructing artificial palates and for the illustrations connected with that subject.

I have to thank, also, the Messrs. Claudius Ash and Sons, who have kindly granted the use of their wood-blocks for many of the illustrations.

C. H.

PREFACE TO THE SECOND EDITION.

THAT a second edition of "Mechanical Dentistry" should be so soon required, I hope may be taken as evidence that it has, in some measure at least, fulfilled its purpose. Several alterations have been made in the text, the most considerable of which is in regard to Celluloid. The recent improvements made in the manipulation of this material have made it necessary to re-write the chapter upon this subject.

C. H.

CONTENTS.

CHAPTER I.

IMPRESSIONS AND PLASTER MODELS.

	PAGE
Mechanical Dentistry in 1728	1
Impression Trays	2
Upper Impression Trays	2
Lower „ „	3
Impression Trays for Partial Cases	3
Struck Trays for Special Cases	4
Impression Materials: Wax	5
„ „ Gutta-percha	6
„ „ Godiva and Stent Composition	7
„ „ Plaster of Paris	8
Casting Models in Plaster	13

CHAPTER II.

CASTING METAL MODELS.

Moulding Sand	18
Casting Rings or Flasks	19
Obtaining the Sand Impression	19
Flask introduced by Dr. Hayes	24
Zinc Models or Dies	26
Lead Counters	27
Fusible Metals	28

CHAPTER III.

GOLD.—PLATE.—CLASPS.—WIRE.

Fine Gold unsuitable for "Base" Plates	30
Furnaces, Crucibles, &c.	31

PAGE
Alloying Gold 32
Alloy 34
Melting the Metal 35
Treatment of Scrap 38
Lemel 39
Flatting 41
Wire 42
Wire-drawing 43

CHAPTER IV.

BLOWPIPE.—SOLDERING.

Bellows Blowpipe 44
Hydrostatic Blowpipe 45
Mouth Blowpipe 46
Directions for Sustaining the Blast 47
Soldering 48
Points to be observed in Soldering 49
The Flame 50

CHAPTER V.

STRIKING UP PLATES.—CLASPS.—STRENGTHENERS.

Plates for Edentulous Upper Models 52
Suction Chambers 57
Plates for Partial Cases, Upper and Lower . . 58
Clasps 61
Arrangement of Clasps 65
Fitting of Clasps 68
Strengtheners 70

CHAPTER VI.

THE "BITE" IN WAX AND PLASTER.

Shaping the Wax-biting Block 74
Management in the Mouth 75
Casting in Plaster 76
Articulating Frames 77

CHAPTER VII.

SETTING MINERAL TEETH ON GOLD PLATE.

PAGE

FLAT TEETH 80
BEST METHOD OF FITTING 81
BACKING FLAT TEETH 83
INVESTING AND SOLDERING 85
WARPING OF PLATES 87
FINISHING 89
TUBE TEETH ATTACHED TO GOLD PLATES 90
SWIVELS 95
CEMENTING TUBE TEETH 98

CHAPTER VIII.

VULCANITE WORK.

SETTING UP COMPLETE SETS 99
FIRING MODELS 103
FLASKS AND FLASKING 104
PACKING 110
NEW FLASK AND METHOD OF USING 112
PARTIAL CASES IN VULCANITE 116
VULCANIZERS AND VULCANIZING 118
THERMOMETERS AND GAUGES 121
FINISHING VULCANITE 125
DR. EVANS'S METHOD OF RETAINING CASES IN THE MOUTH BY MEANS OF RIDGES 127

CHAPTER IX.

COMBINATION WORK.

TEETH VULCANIZED ON A GOLD PLATE 129
GOLD PLATE ON VULCANITE 130
PLATE OR WIRE IMBEDDED IN VULCANITE 132
OBJECTIONS TO CERTAIN FORMS OF COMBINATION WORK . 133

CHAPTER X.

PIVOTING TEETH.

	PAGE
Preparing the Root	136
Tube Tooth upon Pivot	139
Flat „ „ „	139
Tooth upon Split Pivot	141

CHAPTER XI.

REPAIRING.

Gold Plates	143
Vulcanite Repairs	146
Resetting the Teeth of Vulcanite Cases	147

CHAPTER XII.

CONTINUOUS GUM WORK.

Furnaces for Gum Work	150
Constructing the Plate "Base"	151
Lining or Backing the Teeth	155
Soldering	156
Application and Fusion of "Body" or "Base"	157
Enamelling	160
Partial Sets with Continuous Gum	161
Repairing Sets with Continuous Gum	164

CHAPTER XIII.

CELLULOID.

Derivation and Manufacture of Celluloid	167
Prospects of Celluloid as a Dental Base	168
Construction of Celluloid Dentures	169
Mr. Gartrell's Machine	171
Manipulating Celluloid by the Injecting Process	173

CHAPTER XIV.

OBTURATORS AND ARTIFICIAL PALATES.

PAGE

EARLY APPLIANCES 177
MODERN ARTIFICIAL APPLIANCES 180
CONSTRUCTION OF OBTURATORS 182
,, ARTIFICIAL PALATES 185
DR. KINGSLEY'S METHOD 190

CHAPTER XV.

VULCANITE.

MANUFACTURE OF VULCANITE 204
TABLE SHOWING THE ELASTIC FORCE OF STEAM . . . 207

CHAPTER XVI.

METALS USED IN DENTISTRY.

GOLD 209
,, TO REFINE BY ACID PROCESS 211
FORMULÆ FOR ASCERTAINING THE AMOUNTS OF ALLOY REQUIRED FOR THE VARIOUS CARATS 213
TABLES SHOWING THE QUANTITIES OF ALLOY REQUIRED FOR PLATE, CLASPS, AND SOLDER 217
PLATINUM 223
SILVER 225
COPPER 226
ALUMINIUM 227
ZINC 229
LEAD, MERCURY 230
SILVER SOLDERS AND SOFT SOLDERS 232

CHAPTER XVII.

PROPERTIES OF METALS, SPECIFIC GRAVITY, &c.

TENACITY, MALLEABILITY 234
DUCTILITY 235

PAGE
Expansion of Metals and Liquids 235
To ascertain the Specific Gravity of Solid Bodies . 236
Table of Specific Gravity of the Metals . . . 237
" Fusing Points of Metals 239

CHAPTER XVIII.

ELECTRO-GILDING.

Battery 243
Amalgamation of Zinc Plates 244
Gold Solution. 245

CHAPTER XIX.

MISCELLANEA.

Thermometer Scales 251
Tempering Instruments and Tools 252
Table for Tempering 255
" of Useful Numerical Data 255
Soldering on Casting Sand instead of Plaster . . 256
Packing Vulcanite directly to the Model without using a Wax Plate 257
Acids used in the Workroom 258
Remedies for Accidents 261

LIST OF ILLUSTRATIONS.

FIGS.		PAGE
1, 2, 3.	Complete Upper Impression Trays	2
4, 5.	,, Lower ,,	3
6, 7, 8.	Partial Impression Trays	3
9, 10.	Upper and Lower Plaster Models pared into shape	16
11, 12.	Models showing peculiar difficulties with respect to casting in Sand	22
13, 14.	New Method of casting in difficult cases	23
15, 16, 17.	Dr. Hayes's Casting Flask	25
18.	Fletcher's Stove for Zinc and Lead melting	26
19.	Punches for dressing Zinc Models	27
20, 21.	Draught Furnace for Gold	31
22.	Gas ,, ,, (Fletcher's)	32
23, 24.	Ingot Moulds	33
25.	Rollers for Gold	41
26.	Draw-plate for Wire	42
27.	Drawing Tongs	42
28.	Bellows for Blowpipe	44
29.	Hydrostatic Machine for Blowpipe (Richardson)	46
30.	Ordinary Mouth Blowpipe	46
31, 32.	Shears and Punching Pliers for Plate	55
33.	Wire Clamps	58
34.	Zinc Cast, with Teeth reduced to facilitate swaging	58
35.	Steel Punch for chasing	61
36.	Bicuspid Tooth, showing the ineffective action of a wire clasp	62
37.	Bicuspid Tooth fitted with plate clasp	62
38.	Canine ,, ,, ,,	64
39.	Bicuspid ,, ,, ,,	64
40.	Molar Tooth, showing the height to which the clasp may be made	65
41.	Model with Plate, showing the action of clasps	67

FIGS.		PAGE
42.	Model showing how clasps should be placed	68
43.	Lower Plate and Strengthener clamped and ready for soldering	72
44.	Model with added Block for Bite	76
45.	,, Bite cast	77
46.	Articulating Frame (Graham and Woofs)	77
47.	Bite cast to Articulating Frame	78
48.	Lathe for grinding Mineral Teeth	81
49.	Model with Traced Lines, showing the best method of fitting teeth to plate and gum	82
50.	Perforating Pliers	83
51.	,, ,, (Dr. Mallet's)	84
52.	Cutting Pliers	93
53.	Upper Plate with "Standard" tied, ready for soldering	96
54.	Swivels with Bolts	97
55.	Set of Teeth on firing model	103
56, 57, 58, 59.	Vulcanizing Flasks	104
60.	Upper Set imbedded in lower part of Flask	105
61.	Glass for ascertaining the amount of Vulcanite required for any case	108
62.	Heater for Vulcanite	109
63.	Press for closing Flasks after packing	111
64.	Three-part Flask (Hunter)	112
65.	,, ,,	113
66.	,, ,,	113
67.	Vulcanizer	118
68, 69, 70.	Hayes's Vulcanizers	119
71, 72.	Whitney's Vulcanizers	120
73.	Steam Gauge for Vulcanizer	121
74.	Riffler for Vulcanite	126
75.	Cutting Tool for finishing between the teeth of vulcanite cases	126
76.	Scraper for Vulcanite	126
77.	Section of Jaw, showing the conformation taken advantage of by Dr. Evans for the placing of ridges or spurs upon palate cases	128
78.	Pivot Tooth (tube) in section	139
79, 80.	,, (flat) back and side view	142
81.	Muffle Furnace	151
82.	,, ,, (gas), Fletcher's	152

FIGS.		PAGE
83, 83A.	Celluloid Machines	174
84, 85.	Artificial Palates (Stearns)	179
86.	Obturator attached to Skeleton Gold Plate	185
87.	Model of Defective Palate	186
88.	Artificial Set of Teeth, with palate attached	187
89.	Model of Defective Palate	188
90.	Set of Teeth and Artificial Palate attached by joint	188
91.	Parts of which Artificial Palate (Fig. 90) is composed	189
92.	Model of a Case of Congenital Fissure	190
93.	Artificial Appliance for same	191
94.	,, ,, in position upon model	192
95.	Plaster Impression for a case of Congenital Defect	196
96.	Artificial Palate made in two pieces	199
97.	Moulds in which the Appliance (Fig. 96) is vulcanized	200
98.	Appliance completed and ready for insertion	201
99.	Moulds required in order to make Palate in one piece	202
100.	Frame in which the Mould is held during vulcanizing	203
101.	Smee's Battery	243

MECHANICAL DENTISTRY.

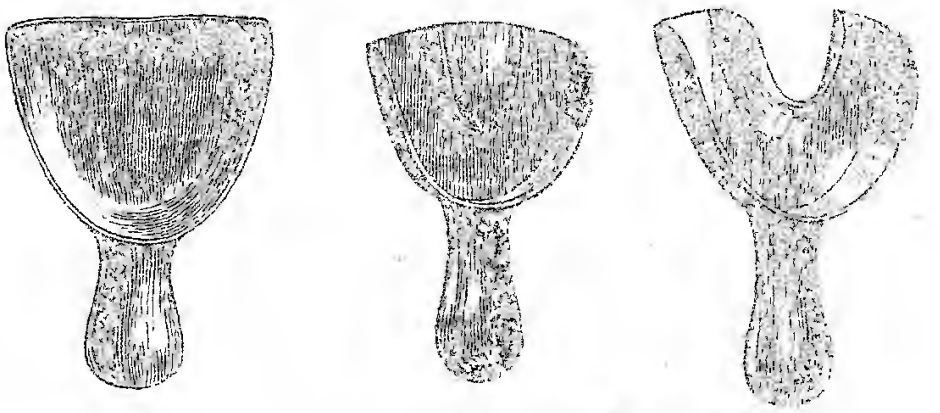
CHAPTER I.

IMPRESSIONS AND PLASTER MODELS.

THE method of practice adopted by the earlier dentists in the construction of artificial teeth was, as may be supposed, very different and much less satisfactory than that which is pursued at the present day. Measurements by means of compasses were first taken of those parts of the jaw for which the artificial teeth were required, and by the indications thus obtained a piece of bone was cut into an approximate adaptation to the space to be filled; the natural gums and teeth were then coloured—as we would colour the plaster model now—in order that fine fitting might be accomplished. Such was the method adopted by Fauchard, and explained in his work published in 1728; and it was not till many years afterwards that the practice of measuring was superseded by that of obtaining an impression of the jaw by means of softened beeswax. At first the piece of wax was held by the fingers and pressed by them into the form of the gum; but it was afterwards discovered that when the soft material was placed in a metal tray of such shape

as freely enclosed the parts of which an impression was desired, and pressed by means of this tray into the shape of the jaw, much more satisfactory results were obtained. Wax as an impression material is now seldom used, composition (Godiva, or Stent) or plaster of Paris being now almost invariably employed for that purpose.

Impression Trays.—The ordinary trays or frames in which the material is placed when an impression of the mouth is taken are made of Britannia-metal, porcelain, German silver, and sometimes

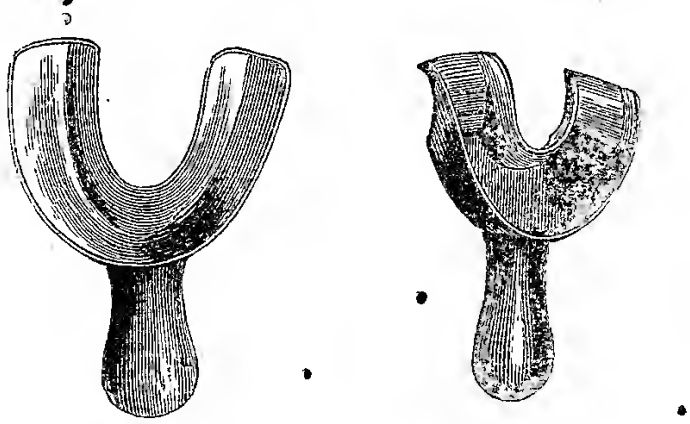


Figs. 1, 2, and 3. Complete Upper Impression Trays.

silver and vulcanite. Those most generally employed are made of Britannia-metal. For complete upper or suction cases trays similar to those shown in Figs. 1 and 2 are used; while for uppers which are not designed for suction—that is, those in which it is not intended to cover the palate with the gold or vulcanite "base" plate—the tray represented by Fig. 3 may be employed.

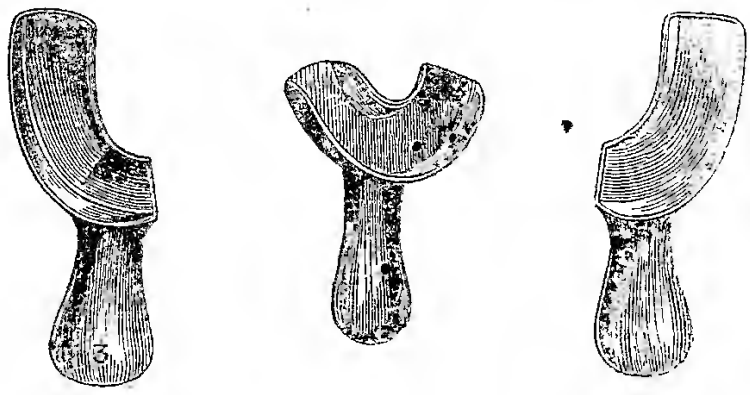
For edentulous lower jaws, and for lowers in which the front six or eight natural teeth remain, such trays as Figs. 4 and 5 respectively are used.

When only a small partial impression of the jaw is required—as is often the case when a substitute consisting of a small number of teeth is to be provided—the tray represented in Fig. 7 is used if the



Figs. 4 and 5. Complete Lower Impression Trays.

deficiency occurs in the front of the mouth, and those represented in Figs. 6 and 8 are employed if the substitute is required for either side. The



Figs. 6, 7, and 8. Partial Impression Trays.

choice of trays for these partial cases, however, depends not only upon the position of the space to be filled, but also upon the position of the natural teeth which will best support the artificial case in

the mouth; therefore it is frequently necessary to use a large tray, in order that the accurate impression of distant teeth may be obtained. A selection of about fifteen trays, differing in dimensions, is necessary in order that the practitioner may be provided with such as are required in every-day practice. Most dentists, however, have a much larger selection.

For special cases where a good impression cannot be obtained by the ordinary means, trays are sometimes made by the dentist himself in the following way. An impression of the jaw is taken with wax or composition, in an ordinary tray (see pp. 6, 7). Into this impression plaster is run, and a model made.* Upon the plaster model softened gutta-percha or wax, about an eighth of an inch thick, is pressed, covering both teeth and gums, and extending in all directions as far as the more perfect model may be desired to reach. A zinc die and lead counter are then obtained, and a plate of Britannia-metal or sheet zinc is struck to the full size indicated by the wax covering on the model. A piece of metal is then soft-soldered to the bottom of the tray to serve for a handle. This may be done with the blowpipe flame, touching the joint with the soldering liquid described at page 233. The amount of impression material which should be placed in a struck tray is of course very small compared with what is required for the ordinary kind. The material, in fact, should be in the form of a layer but little thicker than the covering upon the model. By this means very accurate impressions may be obtained in

* If this paragraph should not be quite clear, Chapters I. and II. should be first read, and this matter reverted to.

difficult cases with the composition. A struck tray is never employed when plaster of Paris is the impression material; in these circumstances, if it be desirable to use a special tray, one may be made from gutta-percha which has been pressed into shape on the plaster model, a piece of iron wire bent into suitable shape being heated and imbedded in the gutta-percha to serve for handle (see pp. 183—196).

Impression Materials.—(*a*) *Wax.*—This substance is frequently adulterated with farina, resin, stearine, &c.; it is therefore necessary to exercise care in its purchase. The following is a simple method of testing its purity: "Pure beeswax becomes kneadable at about 85°, and its behaviour while worked between finger and thumb is characteristic. A piece the size of a pea being worked in the hand till tough with the warmth, then placed upon the thumb and forcibly stroked down with the forefinger, curls up, following the finger, and is marked by it with longitudinal streaks."*

The blocks of wax as purchased should be broken with the sharp blow of a hammer and chisel, and melted in a pipkin (over boiling water); the wax is then poured upon plates which have been slightly oiled. The discs obtained in this manner can be readily softened, and each of them should contain sufficient material for an upper or lower complete model. Wax may be softened by dry heat or by warm water. By using the former, the working qualities are retained longer in the wax than when water is used. Whichever method be

* Barnard Proctor.

employed, however, careful application of the heat is necessary, so that the material shall be made sufficiently soft without bringing it near the melting point. Wax melts at 190° F., and the heat recommended for the water in which it may be softened is 120° to 130° F. When soft it is kneaded by hand, rolled to shape, and placed in the impression tray—which should be first heated slightly in order to make the wax adhere to it. The impression is then taken, greater force being required in the upward pressure than that required for composition or plaster. "Some practice is necessary," Mr. Harris says, "in knowing the proper quantity of wax to use in the cup; the usual mistake is to take too much." This applies still more when composition or plaster is the impression material; for these being much heavier than wax, there is so much the greater tendency for (in the case of uppers) the material to fall away from the surface to which it is pressed. The wax should be moulded, when placed in the tray, into a rough outline of the mouth to which it is to be applied; this will enable the operator to do with less material and less pressure than would otherwise be necessary.

(*b*) *Gutta-percha.*—This substance is much valued by some dentists, as giving most accurate impressions, and being especially useful for under-cut cases. The general experience seems to be, however, that gutta-percha is not to be depended upon for this purpose, the shrinkage which it undergoes after withdrawal from the mouth being very considerable. To avoid this shrinkage, it has been recommended to leave it till it becomes perfectly

hard before withdrawing; but then it will be found in under-cut cases that it is impossible to *withdraw* the impression. If the dentist should ever experience this, the best plan he can adopt for extracting the tray and material is to soften the latter by means of warm water. Time must be allowed, and as the mouth becomes inured, the temperature of the water given may be increased, until the gutta-percha shall be softened sufficiently for withdrawal. To prepare this substance, heat it in water slightly under boiling point, and dry it before placing in the warmed impression tray.

(*c*) *Godiva, or Stent, Composition.*—By means of this composition impressions may be obtained with much more accuracy than with wax, though with less accuracy than with plaster. It does not, however, demand so much from both operator and patient as the latter substance, and its inferiority is perhaps so little as to make it preferable in many cases where a plaster model is not easily obtained. Therefore we find the composition used generally for partial cases, while for edentulous uppers or lowers plaster is employed. It is softened in water of a somewhat higher temperature than that required for wax; but the water should never be allowed to reach the boiling point, as over-heating destroys the material. The tray is filled in the manner already described. In taking the impression less force is required than for wax, and the material must be kept in position while setting by preserving a steady pressure upon the tray. When the composition has become sufficiently hard, the impression is withdrawn from

the mouth, and cold water should be allowed to flow over it.

(*d*) *Plaster of Paris.*—This is generally recognised to be the material which gives the most perfect impression of the mouth. The plaster for this purpose should be new and of the best quality. It must be carefully mixed, and this should be done in or as near the operating-room as possible. It is generally found necessary to mix with the water, before adding the plaster, a small quantity of salt or other substance which will accelerate the setting. The quantity of this setting-mixture to be used altogether depends upon the condition of the plaster at the time of mixing. New plaster, for instance, requires more "hastening" than that which has been some time in use. Where there is any doubt about the setting-time of plaster, a small quantity should be mixed as a test, and the time noted that it takes to change from the consistence of molasses to the condition when it will *break*. The mixture can then be applied, so as to accelerate up to the desired time.

The proper quantity of water and setting-mixture having been placed in a small basin, the plaster is added in a careful and equal manner until it reaches the surface of the water; it is then mixed thoroughly and filled into the tray. The plaster should be left higher in the centre, so that on introducing it into the mouth it will come first in contact with the palate. When it shows a disposition to retain the form given to it with the knife or spatula, it is in a proper condition for placing in the mouth and taking the impression. Another

guide for this is when the tray can be turned over without spilling the plaster. For very high palates a little plaster is sometimes taken from the basin on the point of the forefinger, and placed directly on that part of the palate just before introducing the tray.

With regard to taking the impression, Mr. Coles says: "The great secret of saving your patient any discomfort is just to have the right quantity of plaster in the tray to suit the case, and then with a steady hand place it well back in the mouth before you let it touch the teeth. After this bring the free borders of the back of the tray into contact with the superior part of the palate, and then press upwards from behind forwards until the whole of the tray embraces the dental arch. Adopting this plan secures two points: you prevent the plaster falling backwards and falling upon the base of the tongue to produce retching, and also bring the overplus to the front of the mouth, where it is visible and therefore more manageable. When the plaster that remains in the basin will break with a clean sharp fracture the impression must be removed from the mouth. Air having been let in at the sides by drawing away the cheeks and lips, steady downward pressure must be applied to detach the mould from the teeth and gums. At this part of the process there must be no hesitation on the part of the operator, as every moment the hardness of plaster is increased and the difficulty of safe removal becomes greater." For edentulous and many partial cases the ordinary tray, filled in the manner described, will give the best results.

Where the teeth standing in the mouth are leaning towards each other, however, or are what is called under-cut, a plaster impression so taken would occasion much trouble, so that it is advisable to provide in a special way for overcoming these difficulties.

We may do this either by altering the arrangement in the tray, so that on withdrawing the impression, the plaster will readily break at the difficult points, and in such a manner that it can easily be joined again, or we may make such a temporary change upon the standing teeth themselves as will enable the impression to be readily withdrawn.

The first can be effected in the following manner. Take an impression in Godiva or wax in the usual way, and scoop out this over palate and gums to the depth of at least an eighth of an inch, and freely about the teeth, leaving, however, the border of the impression standing to the breadth of about an eighth of an inch. This forms a shallow box, into which—the surface having been roughened—plaster is filled, the narrow border which has been left across the palate being a guide as to the quantity required, and also serving as a dam to prevent the escape backwards of the plaster. The model is taken in the manner already described for this material, and, when withdrawn, the plaster will readily break at the under-cuts. The pieces are then collected, placed back in position, and fastened with cement at the bench.

Professor Austen advocates another method, but on the same principle: "Take a wax impression

and make a model; in partial cases brush over the teeth of the model one or two layers of thin plaster, to fill up all under-cuts, and to make the plate fit loosely; saturate the model with water and mould over it a gutta-percha cup. It should be on the inside from a $\frac{1}{4}$ to $\frac{1}{2}$ an inch thick, so as to be stiff and unyielding; but on the outside, next the lips, not more than $\frac{1}{8}$ or $\frac{1}{16}$ thick, so as to be slightly elastic and yielding. The whole inside of the cup must be roughened up with a scaler or excavator in such a way that the plaster can take firm hold. In most partial cases the impression must be removed in sections, the inside remaining entire, but the outside and the parts between the teeth coming away separately. In very difficult cases it is necessary to partially cut into the cup, so as to permit its removal in sections with the plaster adherent. These cups have no handle, but are removed by inserting a plugging instrument into a small hole previously made in the back part of the cup where it is thickest."

The other principle upon which these difficulties are overcome is to make such alterations in the mouth itself as will permit the withdrawal of the impression. This is done by first of all drying the parts, and filling in the under-cuts with softened wax or clay; the impression is then taken with an ordinary tray filled with plaster.

Preparation of Impressions previous to casting in Plaster.—Those taken with Godiva or with wax should be thoroughly cooled by running cold water over them before they are worked with; and *all* impressions must be perfectly cleansed from the

saliva or blood which may adhere to them. Blood is generally found upon impressions where the roots have been filed, and if allowed to remain it will rot the plaster it comes into contact with, and thus injure a part of the model it is most important to retain perfect. The surfaces of the composition or wax may be cleansed by using cold water and a camel-hair brush. For plaster impressions hot water may be employed. Teeth standing by themselves must be supported in the plaster model; therefore it is necessary to insert pins into the depressions which indicate their position in the impression material. These pins may be of copper or iron wire, of the thickness used for tube teeth, and should be of varying lengths. Each pin should be about double the length of the tooth it is meant to support. Where the impression of the tooth goes right up to the metal of the tray—as often happens with long incisors—the pin should be bent at one end to a right angle for about an eighth of an inch; the short end is then inserted in the back or face of the tooth, near its apex. For Godiva the wire must be heated slightly before inserting, and held in position until the material hardens round it; for plaster, a hole must be drilled for its reception.

The surface of composition and wax impressions may receive a very thin coating of oil. The surface of those taken with plaster must receive a very thorough and careful coating before casting, or the parting from the model afterwards will not be easily or safely accomplished. Oil may be used for this class of impression, in which case several

coatings must be given. Parting liquids are sold by the manufacturers for this special purpose; and Harris gives the following as suitable parting substances: "1st, a varnish of sandarach, or shellac, or of dilute soluble glass, with a little oil upon the varnished surface when dry; 2nd, by saturating the impression with as much oil as it will take up without standing upon its surface; 3rd, by coating with a dilute soap mixture." The first—varnish—is liable to dull the sharpness of the impression, and is therefore objectionable. Perhaps the most suitable is the soap mixture, carefully applied with a camel-hair pencil.

Casting the Plaster Model.—It is of great importance that, whether for vulcanizing upon or for plate work, we should have what is called a "hard model." The only way known in which we can obtain this is by mixing the plaster thick—that is, with as much plaster to the water as we can make it take up.

None of the substances described as having the power to harden plaster have really any influence in that direction. After a little practice it may be mixed and shaken into the impression in a thicker state than might at first have seemed suitable for that purpose; and if it be made in this way, and the drying be properly done, a strong hard model will be the result. When the plaster has been mixed, the impression is taken in the left hand, and the plaster is introduced (with the knife or spatula) at one end of it—that would be in a full upper on the slope leading down to the last molars; from this the plaster must be made to flow right round and

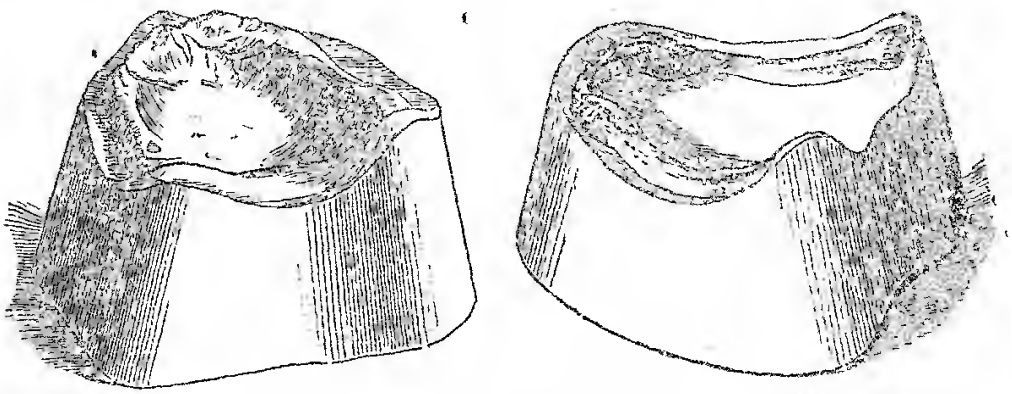
over the impression. This is done by tapping the bottom of the tray upon the bench continuously, while the plaster is being added at the part referred to only. Care must be taken not to strike against the impression material while filling it with plaster; and in the case of the more fragile impressions some kind of cushion should be used for striking the under surface of the tray against. By filling in this way (from one point only of the impression) the air is expelled before the advancing plaster in a harmless and regular manner: if the latter be introduced on the other hand at *different* parts of the impression, it flows together and *encloses* the air, and a more or less false model is the result. When the impression is once covered, the plaster may then be quickly added to a thickness of about a quarter of an inch. If the model is for a vulcanite case no more building is necessary: it is allowed to harden, when the further stages are proceeded with. For a "plate" model, however, it must be built much higher, and this is done whenever the plaster in the basin becomes thick enough to "hold" or retain itself in shape. It is then taken out of the basin, and formed, upon a square of paper or glass placed on the bench, roughly to the height and shape of the model desired. The impression tray is next taken, and, being turned over, its plaster is pressed down into that just built upon the glass, a knife or spatula being used to draw up the one plaster over the other, and also to improve the shape, so far as that can be done while the model is in this soft condition. Only a little practice is required to make this the quickest and

in all respects, the most satisfactory method for casting a model in plaster. The latter must then be allowed to become thoroughly hard before attempting to separate it from the impression material.

The separation of wax from the plaster model may be accomplished by dry heat or by warm water. If the former be employed the heat should be allowed to come to the wax through the plaster; a moderately hot iron plate, if the model be laid upon it, will answer the purpose well. In either case over-heat must be avoided, and the wax only softened so far that in drawing it from the model the plaster teeth will not be in danger of breaking. For composition hot water only should be used. The model, being placed tray downwards in the water, should remain, where there are teeth standing at least, until the impression material has become soft throughout, before separating. Where plaster has been employed for the impression very great care must be taken. If colouring matter has been mixed with the impression plaster, the line of separation between it and the model will be more readily observed. The separation, in many cases, is effected by gently tapping the tray and enclosing border of plaster; generally, however, it is necessary to *prise* the impression plaster away from the other. Before doing this it may be an assistance to heat the parts. Mr. Coles says they "should be placed in a basin of boiling water and allowed to remain for two or three minutes. The heat produces expansion of the plaster, and the one portion (the impression) having been mixed earlier than

the model this expansion is unequal and thus starts the division of the impression."

Supposing the model to be for a plate "base," it must then be pared with the knife, so that it shall part easily from the sand in the process of sand-moulding. For this purpose it is not only necessary to cut the sides with such a slope that will enable the model easily to drop from the sand, but such parts as are not intended to be covered by the plate, and are likely to grip in the sand, must be filled either *now* with plaster or afterwards (after



Figs. 9 and 10. Upper and Lower Plaster Models pared into shape.

waxing the model) with wax. The accompanying figures represent an upper and lower model pared into shape.

Some dentists would now at once proceed with the sand moulding; but the usual practice is to "dry" the model at this stage and wax or varnish its surface. For this purpose it should be placed at the fire in such a position as will insure the heat being *gradually* raised to a point beyond what can be easily borne by the hand. The model is then dipped, by means of a stout thread tied round it,

into the mixture, which by this time should be melted and *hot*.*

If both are in proper condition the mixture will at once boil up over the model, which may remain thus covered for about a minute. It is then withdrawn, and, the adhering mixture having been drained off, is laid aside to cool. From a quarter of an hour to an hour may be given for "drying" a model. But it should be remembered that though by under-drying the hardest possible model is not obtained, over-drying is accompanied by much more serious results; for it will be found that a model which has been allowed to remain for a considerable time close to a strong fire, and then waxed, is quite unfit for use. Therefore it is necessary to attend carefully to the heating of the model; and it would perhaps be better to say "wax the model when it is hot" rather than "when it is dry."

* The mixture in which models are "boiled" is generally composed of from one to two parts resin to one part wax; sometimes stearine is used for this purpose.

CHAPTER II.

CASTING METAL MODELS.—SAND MOULDING.—ZINC.—LEAD.

Moulding Sand.—The sand employed by dentists for this purpose is the same as that used by brass-founders.

It must be made sufficiently damp with water to give the necessary cohesion to its particles, and that which is to come in contact with the model must be fine grained in order to take a sufficiently sharp impression of its surface. Sand which when closed in the hand takes a good impression of its lines, and breaks with a clean fracture, may be said to be in proper condition for moulding.

But in preparing this material, and in the subsequent operations, it is necessary to remember that the conditions which are most favourable to obtaining a good impression in the sand—viz. dampness, fineness of the grain, and tight "ramming"—are most unfavourable for the reception of the melted zinc which is to be poured into it. So that with over-damp and tightly consolidated sand the zinc will boil and an imperfect model will certainly result. Or if only the necessary dampness has been given,

still, if the sand be tightly packed, there will be the same unsatisfactory result.

The explanation is, that when the melted metal comes in contact with the sand steam is immediately formed, which, if the latter be loosely packed, will escape harmlessly through the pores; but if, on the other hand, the sand be solid, then the steam cannot escape in that way, but struggles through the metal, causing it to "boil," and a false model is generally the result. The sand which is to come in contact with the model may be fine grained, but the flask or ring should be filled up with a coarser kind.

Casting Rings or Flasks.—These are sometimes in the form of a square wooden frame; but generally iron rings are used for this purpose, of very simple construction, being merely a hoop of cast-iron, greater in height and circumference than the model to be cast in it, so that sufficient space may be left between the model and iron in all directions for the sand in which the former is to be enclosed.

The casting ring is placed upon the bench, and the model, after being brushed with parting powder (lycopodium, or French chalk), is placed in the centre of the ring. The fine sand is now dropped over the palate, &c., and this is followed by the coarser kind, sufficient pressure being used to carry the sand into all the irregularities of the model. The ring is now filled up with the coarser sand, and it must not be "rammed" solid, but only sufficiently tight to prevent it from giving way in the subsequent handling. A knife should be drawn across the superior border of the iron ring, to give the

sand a perfectly level surface. The mould is now lifted perpendicularly by the left hand a few inches from the bench, and a few taps over the bottom surface of the model with a riveting hammer will suffice to disengage it from the sand.

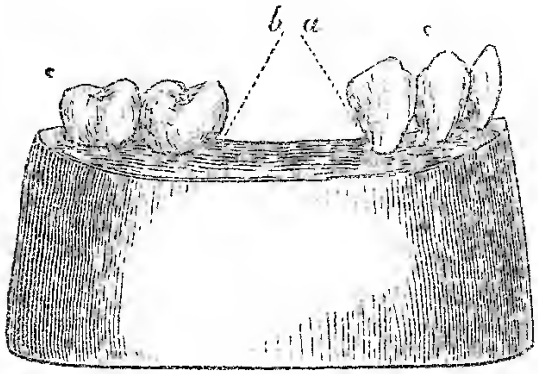
Another method of taking the model from the sand may be adopted. After filling the ring and levelling the surface, the mould is turned over, so that this surface shall be next the bench (which must be clear of sand and flat). The model is then gently tapped over the surface with the hammer, and lifted out of the sand as it becomes loosened, either by means of a pointed tool or screw sunk in the plaster, or by inserting the thumb and forefinger just enough to grasp the model at opposite points; while it is so held with the left hand the hammer is used in the right. This method of bringing away the model we decidedly prefer for the following reasons. When this plan is adopted, portions of the sand impression which may become detached still remain in the mould, and can, with careful treatment, be pushed into position again; but when the model is dropped out, as in the first method, the detached sand falls with it, and cannot be replaced. Again, it is possible to humour a model when lifting it out, so as to preserve an under-cut, which would break away if the other method were employed. For example, an edentulous upper, with an under-cut in front, may often be withdrawn in this way without injury, if the sand be first cut from the back wall of the model to allow for the necessary movement. Where it has been considered necessary to use fine sand tightly consolidated, an escape may

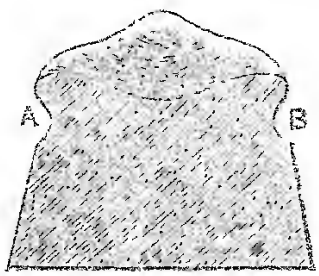
be provided for the steam by piercing the sand with a broach over the surfaces not required for the fitting of the plate; for example, the palate may be treated in this way when only a narrow gold plate is to be fitted to the model.

The majority of models may be obtained by the methods just described; but others are met with presenting difficulties not so easily overcome. Partial cases, for instance, where the teeth, from their shape and inclination, make it impossible to withdraw the model without destroying the impression; and edentulous cases also, where undercuts extend along both sides of the model. In the former—partial cases—the difficulties are got rid of, when the teeth causing the trouble are to be *clasped*, by removing the complicating teeth from the model previous to taking the sand impression. In order that they may be removed satisfactorily, and so that they may be *replaced* perfectly, it is necessary to have this point in view when inserting the iron or copper pins into the impression material before casting the model in plaster. The pins should be straight and slightly bevelled, and the *thicker* end inserted in the impression material. Before taking the model in sand, the teeth to be clasped and likely to cause difficulty are cut round their necks with the fine bench saw, but only so far that by a slight rotary pressure a clean fracture across the neck will take place, and the tooth and *pin* will leave the model together. An otherwise impossible impression may now be taken with ease; and the teeth may be returned afterwards to perfect position, a little cement from a hot knife being used to

fix them. It will be observed that if the pins had not been bevelled as described, they would probably have remained standing in the model when the teeth were removed.

Where this method cannot be adopted the under-cuts may, in many instances, be filled out with wax to simplify the sand moulding; for there is a considerable number of cases of this description in which a perfect fitting of the plate into the under-cuts is undesirable; Fig. 11 shows such a case, where it would be impossible to insert in the mouth



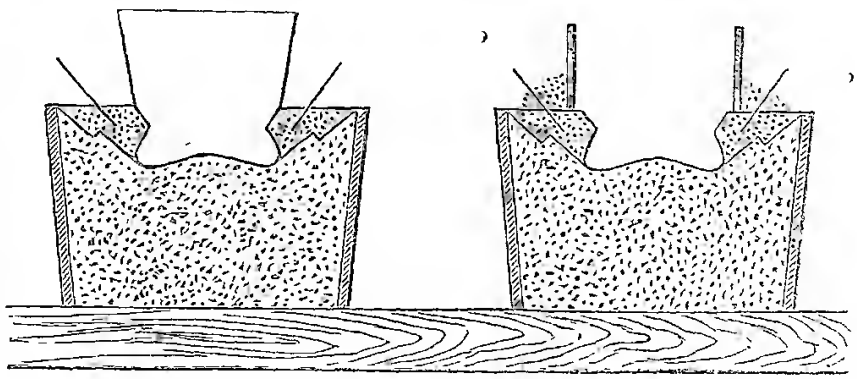


Figs. 11 and 12. Models showing peculiar difficulties with respect to casting in Sand.

a plate fitting perfectly to the under-cuts here indicated. In other cases again we might make an addition, for the purpose of facilitating the moulding, which may easily be taken away with file or punch from the zinc cast.

By the means already noticed we are enabled to succeed with all but a few cases of special difficulty, and these include edentulous uppers, where the under-cut extends along the outside of the alveolar ridge on both sides of the jaw. The figure shows a section of a model with these under-cuts at A and B.

In such a case we fill a casting ring loosely with sand, and, when filled above the level of the ring, consolidate the surface slightly with the hand. Now take the plaster model and press it perpendicularly down upon the sand until the impression is buried about an inch, when the sand is pressed compactly between the ring and model. A knife is now used to cut a wedge-shaped block from each side, which will thus leave the under-cut parts entirely exposed, and the model is withdrawn. The surface of the cut sand may now be more carefully shaped



Figs. 13 and 14. New method of casting in difficult cases.

and made as *smooth* as possible. Parting material* is then shaken over these prepared surfaces, and the model, which should also be brushed with chalk or lycopodium where it comes into contact with the new sand, carefully replaced. The prepared spaces on each side are now filled with the finest sand, made thoroughly cohesive and consolidated as well as the circumstances will permit (Fig. 13). While packing these side blocks, one end of a short length of binding wire may be left imbedded, by

* The best parting substance for this work is sand which has been dried by heat and reduced to fine powder.

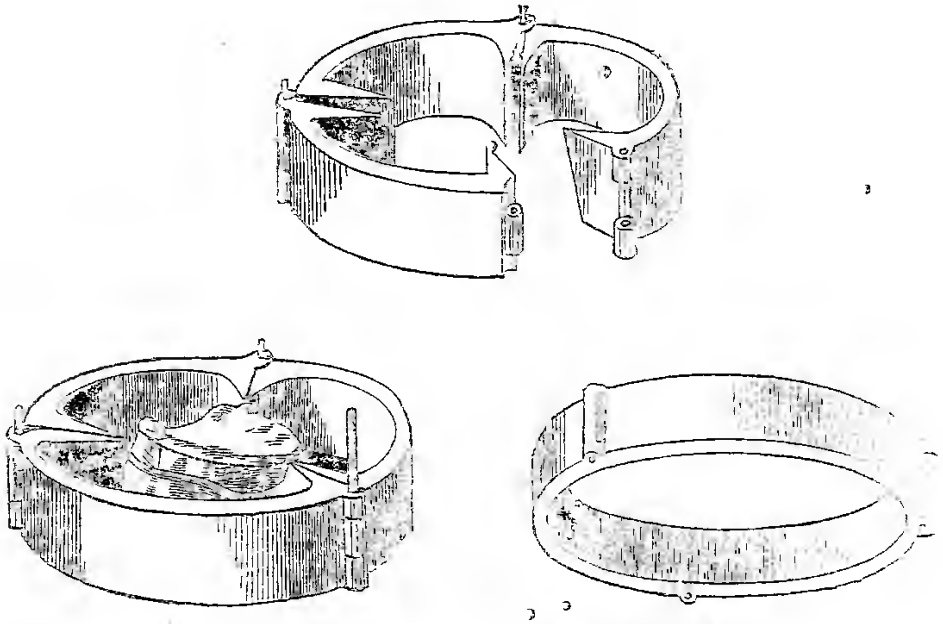
which they can readily be moved. The model is now slightly tapped, the cores drawn gently aside, only sufficient to allow the model to pass, and the latter is withdrawn. The cores are returned to the exact position, and the zinc might now be poured; but before doing so we must provide means for obtaining a thicker and stronger zinc. For this purpose an iron shape, represented in section in Fig. 14, must be placed lightly upon the sand, which will give its own form to the metal—an upper part of a vulcanite flask for instance comes very near the shape required. Some fresh sand should be gently placed against the shape all round, in case the metal should escape.

This method of taking difficult impressions by means of cores has been described with reference to edentulous cases only; but of course the same system may be adopted with partial cases presenting similar complications.

By one or other of the methods explained a means will, we think, be found for casting models of every description, and that in the readiest and simplest manner. A moulding flask, however, was introduced several years ago by Dr. Hayes, which was specially designed to overcome the difficulties met with in the class of models we have last described. This flask has not, however, come into general use; the complication of parts may partly explain why it has never become a favourite with practical dentists, but besides this it may be said that though the theory upon which it is constructed is correct, the theory is one which cannot very easily be perfectly carried out in practice.

Figures 15 and 16 represent the lower section of this flask. In the former figure the joints are opened slightly to show the movement of which it is capable; in the latter the same section is seen closed with a model in the centre placed ready for sand casting. Fig. 17 represents the upper section of the flask.

To cast by means of this arrangement, the lower



Figs. 15, 16, and 17. Dr. Hayes's Casting Flask.

section must be closed and the joint secured by a pin, and the model placed as shown in Fig. 16. Should there exist between the sides of the model, when so placed, and the flanges, or projecting points of the flask, a considerable space, slips of paper may be placed in the joints which shall reach to the sides of the model: this will facilitate the parting of the sand which afterwards takes place. Now fill in the sand around the model until

the most prominent line of the gum is reached—that is, until the under-cuts are enclosed by the sand—and smooth the sand surface. It is then necessary to cover the latter and the exposed surface of the model with a film of pulverized charcoal; join the upper section of the flask to the lower, and complete the moulding by filling with sand. When this has been done the two sections are separated; the pin securing the joint of the lower is then withdrawn, and that part is opened so far as to permit of the model being removed without injuring the sand impression. After the removal of the model the parts of the flask must be accurately readjusted and secured; the metal is then poured in the usual manner. The greatest care must be observed in separating and in reclosing the parts when working with this flask, for it will be seen that, unless the readjustment is perfectly accurate most unsatisfactory results will be obtained.

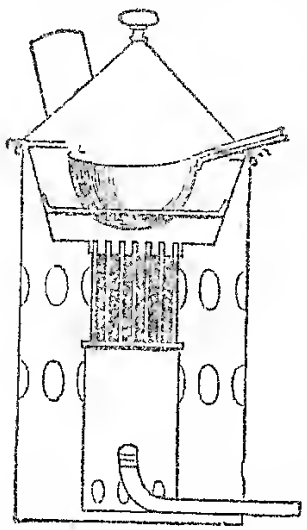


Fig. 18. Fletcher's Stove for Zinc and Lead melting.

Zinc.—The metal for models and counters may be melted in a gas-stove, in which case a ladle is used (Fig. 18 shows a stove for this purpose, made by Mr. Fletcher, Warrington); or it may be melted on an ordinary fire fitted with a blower, in that case a plumber's pot instead of the ladle should be used, a small ladle being employed to lift the melted metal from the pot and pour it into the mould. Over-heating completely destroys zinc; it should

therefore be carefully attended to while heating, and the mould filled whenever the melting takes place. The small ladle should be heated well before using it for lifting the zinc. Besides preserving the metal in a good working condition, this plan is also, of course, favourable to obtaining a model uninjured by "boiling." After the mould has been filled and the zinc is properly set, the latter is then taken from the sand and cooled. The metal model is now compared with the plaster one, and any defects removed by using the steel punch (Fig. 19) or file.

Fig. 10. Punches for dressing Zinc Models.

Lead.—The counter may now be taken in either of two ways. The melted lead may be poured over the zinc model, or the latter may be "let down" into the melted lead.

To obtain the first, the zinc—which must be perfectly dry—is placed upon the bench, and sand is heaped round it and high enough to reach the margin of the impression. The cast-iron ring which is to give shape to the counter is then placed lightly upon the sand, some of which is banked up over its edges to prevent the lead from flowing under the ring and out of the mould. Into this iron shape, the walls of which rise about two inches above the surface of the zinc impression, and are

slightly inclined so as to facilitate parting, the lead is poured.

To obtain a counter by the other method, the lead is melted and poured into a suitable iron shape, and the zinc, held in the hand or by pliers teeth downwards, is imbedded to the extent required, in the melted metal, and held in position until the latter sets. Or the lead having been melted in a ladle, the zinc may at once be sunk in it, while so held, until the impression is sufficiently imbedded. When set, the lead counter is struck from the ladle, and, being of the same shape as the latter, it forms what some consider a most convenient reverse, especially where it is the custom to do much of the striking upon the knee or in the hand. We prefer to make the counter in the manner first described; it need take no more time than the others, and a good one is perhaps obtained with more certainty.

When the metal models have been cooled in water, they may then be separated by striking the zinc on opposite sides with the bench hammer.

The shrinkage of zinc interferes more or less with the perfect fitting of plates, and some dentists have tried what are called "fusible metals," which have much less shrinkage than zinc. There are objections to the use of the fusible metal models, however, of another kind, which render them unsuitable, so that in regular practice zinc is still employed as the best metal from which the die can be made. The following particulars with regard to fusible metals are given by Professor Austen:

"Type Metal.—Lead, 5 parts; antimony, 1 part. Fuses at 500°, contraction less than one-half that of zinc, more compressible than the latter, and very brittle.

"Zinc, 4 parts; tin, 1 part. Fuses at a lower heat, contracts less in cooling, and has a less surface-hardness than zinc.

"Tin, 5 parts; antimony, 1 part. Melts at a lower heat than either of the preceding alloys, contracts but slightly in cooling, is harder than tin, and sufficiently cohesive. It is readily oxidized, and should be poured as soon as melted."

Fusible Alloys.—The following tabular view of the more fusible alloys, the respective properties of which are deduced from actual experiments, is given by Professor Austen, in a paper on "Metallic Dies" (*American Journal of Dent. Science*, vol. vi. p. 367). Zinc is introduced into the table for the purpose of comparison.

	Melting point.	Contractility.	Hardness.	Brittleness.
1. Zinc	770°	·01366	·018	5
2. Lead 2, tin 1	440°	·00633	·050	3
3. ,, 1, ,, 2	340°	·00500	·040	3
4. ,, 2, ,, 3, antimony 1	420°	·00433	·026	7
5. ,, 5, ,, 6, ,, 1	320°	·00566	·035	6
6. ,, 5, ,, 6, ,, 1 bismuth 3	300°	·00266	·030	9
7. Lead 1, tin 1, bismuth 1	250°	·00066	·042	7
8. ,, 5, ,, 3, ,, 8	200°	·00200	·045	8
9. ,, 2, ,, 1, ,, 3	200°	·00133	·048	7

CHAPTER III.

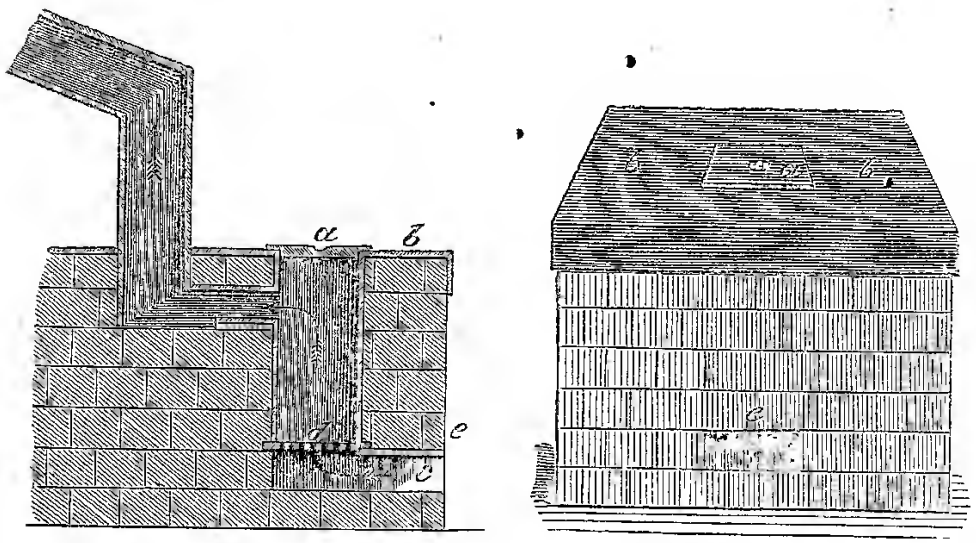
GOLD.—PLATE.—CLASPS.—WIRE.

FINE gold is much too soft to be employed as a "base" plate for artificial teeth; it is therefore necessary to mix with it a certain amount of silver and copper to obtain the hardness required for this purpose.

Four pennyweights of alloy to the ounce of fine gold is sufficient to render the metal suitable for dental purposes; and this is the quality of gold (20-carat) adopted by many eminent dentists for base plates, while they use 18-carat for clasps, &c. The standard favoured by the majority of dentists, however, is 18-carat—6 dwt. alloy to the 18 dwt. of fine gold—for plates, and 16-carat for clasps and wire. It would be more satisfactory if the clasps, &c., were made of the same quality as the main plate, as then we should be able to use solder of a higher quality than is at present possible.

Gold plate and wire, of the various thicknesses and qualities required, may be purchased at the depots; and in practices where there is a constant flow of mechanical work probably that is the most profitable plan to adopt. Where quiet seasons

occur, however, with considerable regularity these may advantageously be turned to account by the dentist preparing his own plate and wire. To accomplish this the following are the chief implements required: furnace, crucibles, rollers, draw-plates. The furnace employed for melting the metal may be the ordinary draught furnace (Figs. 20 and 21), built of brick-work, the chamber in which the fuel and crucible are placed being about 8 inches square



Figs. 20 and 21. Draught Furnace for Gold.

and about 15 inches deep. The sides of this chamber are formed with fire-bricks, and at the bottom is the grate *d* (Fig. 20) which supports the fire; the rest of the work may be done with the ordinary bricks, building up to suitable shape. When this is completed the top forms a flat surface, upon which an iron plate *b* is fixed, which forms a convenient heating surface for many purposes. Or the melting may be accomplished by means of a gas furnace. Of these, the one introduced by Mr. Fletcher, War-

rington (Fig. 22), is best known to dentists, and it is highly spoken of by many. Of crucibles there are two kinds: the clay, and the plumbago or black-lead crucibles; the latter are to be preferred for several reasons. They can be used repeatedly—Mr. Gee says from twenty to fifty times with care—and therefore their original excess of cost over the others disappears. They may be subjected to the greatest and most sudden alterations of temperature without cracking; and, most important of all, their surface, both within and without, may be made very smooth, so that particles of melted metal will not hang about the sides—an advantage not possessed by any other crucibles in the same degree.*

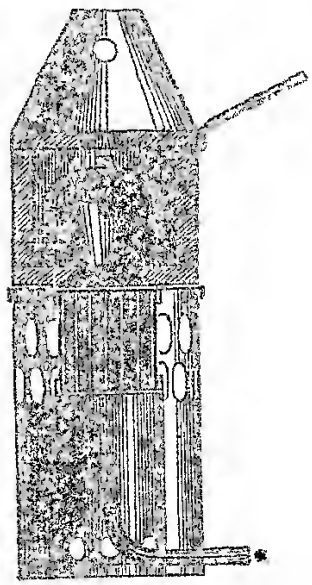


Fig. 22. Gas Furnace for Gold (Fletcher's).

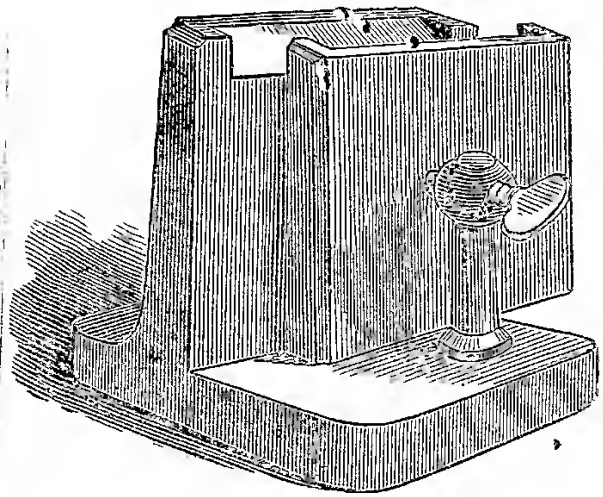
Iron tongs are required for lifting the crucible from the fire, and for pouring the metal into the ingot mould or "skellet."

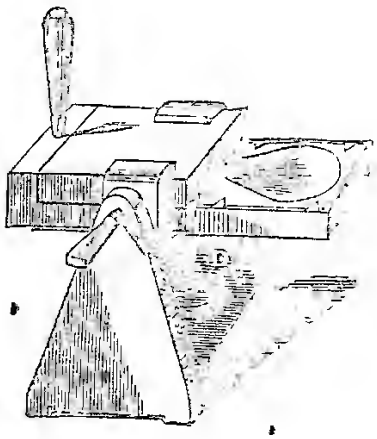
Fig. 23 shows an ingot-mould of the ordinary kind. For small quantities of gold the arrangement shown in Fig. 24 has been introduced by Mr. Fletcher. Here the gold is melted by the blow-pipe flame, when it is made to flow into the mould by turning the latter by means of the handle to a suitable inclination.

Alloying the Gold.—Weighing the alloy for the gold requires strict attention. To prevent the

* Percy's "Metallurgy."

possibility of error, the calculation and weight should be checked by a second person.





Figs. 23 and 24. Ingot Moulds.

With fine gold the amount of alloy required to reduce one ounce to the several carats is as follows :—

				dwts.	grs.		
To the ounce of fine gold add of alloy			. .	4	0	= 20	carat.
,,	,,	,,	. .	5	15	= 19	,,
,,	,,	,,	. .	6	16	= 18	,,
,,	,,	,,	. .	10	0	= 16	,,
,,	,,	,,	. .	14	6	= 14	,,

It is frequently found most convenient to reduce from gold coin, which, being mixed with the greatest accuracy, can be perfectly relied upon as regards its carat value.

The English sovereign is 22 carats fine, and weighs 5 dwts. $3\frac{17}{62\frac{1}{2}}$ grs.; it is therefore worth for melting exactly its value as coin.

When the sovereign is used, less alloy is of

course required than for fine gold; the proportion required for the several carats is as follows:—

To four sovereigns add alloy	. . .	2 dwts. = 20 grs.
,, ,,	. . .	1 dwt. 17 grs. = 17 ,,
,, ,,	. . .	1 dwt. 12 grs. = 12 ,,
,, ,,	. . .	1 dwt. = 10 ,,
,, ,,	. . .	17 grs. = 7 ,,

Alloy.—For gold plate the alloy used is always silver and copper. The proportion in which these are mixed with the gold influences the latter both as to colour and hardness: copper gives hardness and a red tinge to the gold, while silver preserves its softness and gives it a greenish-white tinge. The general rule is, for base plates, to make the alloy of equal parts silver and copper, or with a slight preponderance of copper. For clasps, wire, &c. a very decided preponderance of the copper is given, in order to produce the necessary elasticity; sometimes a few grains of platinum are added for clasp gold. For solder rather more silver is given to the alloy than copper, and sometimes a few grains of zinc.* It must be remembered when coin gold is used to reduce from that the sovereign is already alloyed with $\frac{1}{12}$th copper, so that the alloy to be added must consist mostly of silver, in order that anything like equal quantities of silver and copper may be mixed with the gold. Thus in the four sovereigns there is 1 dwt. 17 grs. of reduced copper; therefore the 4 dwts. 12 grs. of alloy to be added to

* This last addition is condemned by many dentists, while others recommend it, but only in *very small* proportion.

four sovereigns to reduce to 18-carat must be composed of 3 dwts. 2½ grs. silver, and 1 dwt. 9½ grs. copper, in order that the total alloy in the resulting gold shall be equal parts silver and copper.

Formulæ, recipes, &c., regarding gold plate, clasps wire, and solders will be found at pp. 217—221.

Melting.—On this subject Mr. Gee says in his "Practical Gold Worker": "In preparing the mixture of gold, silver, and copper for the crucible, care should be taken in weighing them accurately, in order to prevent improvement or deterioration in the qualities of gold constantly in use. In melting all qualities it is a wise plan to place the lightest of the metals at the bottom of the crucible—viz. the copper first, the silver next, and the gold last;* by so doing, the melter is more likely to get a perfect amalgamation of the metals, as the gold, being the heaviest, is sure to find its way to the bottom of the pot. Plumbago crucibles are the best for all practical melting purposes, and, with care, will last from twenty to fifty times. If new, a very small quantity of charcoal powder should be put into the pot with the mixture of alloy. This coats the surface of it, and prevents the metals from adhering to it. When the gold is at the point of fusion, fling on to it about a table-spoonful of pure and perfectly fine vegetable charcoal. The layer of charcoal which forms upon the surface of the gold in the crucible protects the mixture from the action of the air, which would refine the gold by destroying

* In melting small quantities we have adopted the opposite order—melting first the gold and silver and then adding the more volatile metal, the copper.

some of the gold. When perfectly fused, the mixture must be well stirred with an iron stirrer (consisting of a long round piece of iron sharpened at the point), which should previously be made red-hot, to render the whole mass uniform in quality. The pot is then quickly withdrawn, and its contents poured into a suitable ingot-mould, previously warmed and greased to prevent adhesion. The warming of the mould is quite indispensable; but if made too hot, the metal, on being turned into it, will spit and fly about. Besides incurring great loss of gold, dangerous results may thereby happen to the person in charge.' The same remark applies when the ingot is cold; therefore this part of the process must not be neglected, but carefully attended to. The ingot-mould, we may state, is hot enough when it will just stand touching with the hand for a second or so.

"When it is desired to produce very tough gold, use, as a flux, a table-spoonful of charcoal as before, and one of sal-ammoniac, adding it to the gold on the eve of melting. The sal-ammoniac burns away while toughening the gold, leaving the charcoal behind to perform the functions already indicated.

"For producing tough gold, the employment of common salt as a fluxing agent is sometimes strongly recommended. There is not, however, much to be said for its use, as it produces a very liquid flux, and is not half so clean as the one we have recommended. In the casting, unless very great care is exercised, it runs into the ingot-mould with the gold, producing a brittle-like substance;

and this forces itself into the bar of gold, the surface of which becomes irregular and full of holes. On this account alone, in preparing clean and smooth bars of gold it is objectionable. The same may be said of borax, but that is still largely used in the jewellery trade for melting purposes. Nevertheless, we are confident, from long practical experience (the result of many years' study and practice, during which time we have worked up many thousand ounces of gold), that there is no better flux than the mixture of *sal-ammoniac* and charcoal for *every* possible purpose required in the subsequent treatment of the different qualities of gold; and that for toughness, cleanliness, and producing good workable properties, it cannot be surpassed."

Scraps, or Cuttings and Filings.—These, if kept clean, and apart from the miscellaneous scraps and filings derived from repairs, &c., may, without difficulty, be melted by the process already described. In order to preserve them in this condition, separate trays should be provided for new work and repairs; and that used for new work should be cleared *frequently*, the gold being collected in a box until required for melting. That used for repairs, &c. will contain, even when the utmost care has been taken to exclude them, various substances which will render the rolling and working of the gold with which they are associated sometimes a very difficult if not altogether impossible process. These substances include small pieces of lead, iron, mineral, zinc, and platinum, &c. Iron is to a great extent removed by means of the magnet,

which should be repeatedly drawn through the scrap. Even should *slight* traces of this metal remain, it does not seriously interfere with the working qualities of the gold. It is different, however, with other metals. Tin, lead, antimony, or bismuth, if only forming $\frac{1}{2000}$th part, destroys the ductility of the gold. Exposure to the fumes of red-hot tin or lead renders it hard and brittle. Gold should therefore not be melted in a furnace which has recently been used for these metals. The plan recommended, as the best to adopt in these circumstances, * is to roast the scraps with nitre for half or three-quarters of an hour, adding small portions at a time. The melted metal may then be poured into an ingot-mould. The nitre removes the traces of zinc or iron which may be in the metal. If, after hammering, annealing, and rolling, it should still be found brittle, it must be remelted, and chloride of mercury used as the refining agent. This will remove the traces of lead or tin. Gee recommends that the scrap should be first melted as described for new gold; if the metal should then split in the rolling, remelt it with 2 parts carbonate of potash and 1 part nitrate of potash. Should it still prove brittle, melt again with a flux composed of 2 parts charcoal and 1 part corrosive sublimate (bi-chloride of mercury). When the scrap is very coarse, however, being made up of solder, platinum pins, &c., besides the baser metals referred to, Mr. Richardson advises the dentist to have recourse at once to the "humid" process of refining (that just explained being the

* Richardson's "Treat. on Mech. Dent."

"dry" process). That is to dissolve the metals by means of acids, and then precipitate the *gold* from the liquid. This plan is not to be recommended for this reason, that, apart from the great amount of time and inconvenience connected with it, the cost of chemicals and the loss of gold is out of all proportion to the small amount of metal the dentist requires to refine; so that with the utmost care the money loss resulting very closely approaches what a respectable refiner would charge for doing the work.

When the scrap is in the condition described, the best plan is to melt it with an ordinary flux, afterwards break the crucible, and send the metal to a respectable refiner, who will, as the dentist desires, return the purified gold or its value in money, deducting a small charge for assaying and refining. Should, however, the dentist wish to make a trial of the scrap and filings himself, the following particulars regarding the treatment of lemel will assist him.

Lemel.—This consists of the gold dust and very small scraps, with which organic matter and other impurities are always associated. "Sift the lemel through a fine sieve, to separate the small portions of gold from the dust, letting the lemel fall on a clean sheet of paper provided for the purpose. This should then be carefully put into an iron ladle, and heated until all the organic matter is entirely destroyed. When the burnt lemel has sufficiently cooled, put the magnet through it, in order to collect and remove whatever iron or steel filings may be contained therein. The scrap should

always be separated from the lemel (gold dust). Then take—

Lemel or gold-dust . . .	12 ozs.
Carbonate of potassa	2 „
Common salt	½ oz.
	15 ozs.

Well mix the lemel with the salts, and then place the preparation in a skittle-pot; after which place a layer of common salt on it, and transfer it to the furnace. A greater portion of the mixture should not be put into the crucible than will fill it to within one inch of the top, to be safe, as it rises in the furnace and may overflow. When the fire is at its height, the heat must be continued for half an hour longer. The pot, at the expiration of that time, must be carefully withdrawn, and placed aside to cool, when it may be broken at the bottom with a hammer, and the gold will then be found in a button. A little nitrate of potassa (saltpetre) may be added occasionally when it is in a state of fusion; but the saltpetre must be added with very great care, for if too much be put in, and organic matter be still present, it will rise above the top of the melting-pot and carry some portion of the precious metal with it. This may be prevented, however, by the timely application of a little dry common salt in powder."

The gold produced in this manner will be more or less below the quality usually worked for plate, and the dentist therefore may have to add fine gold in order to raise it to the usual standard.

"The pouring of the gold into the ingot-moulds

is an art which requires some little skill and practice. The flux floating upon the surface of the gold in the crucible may be prevented from passing into the ingot-mould by using a thin piece of flat wood held in the left hand: poplar wood is the

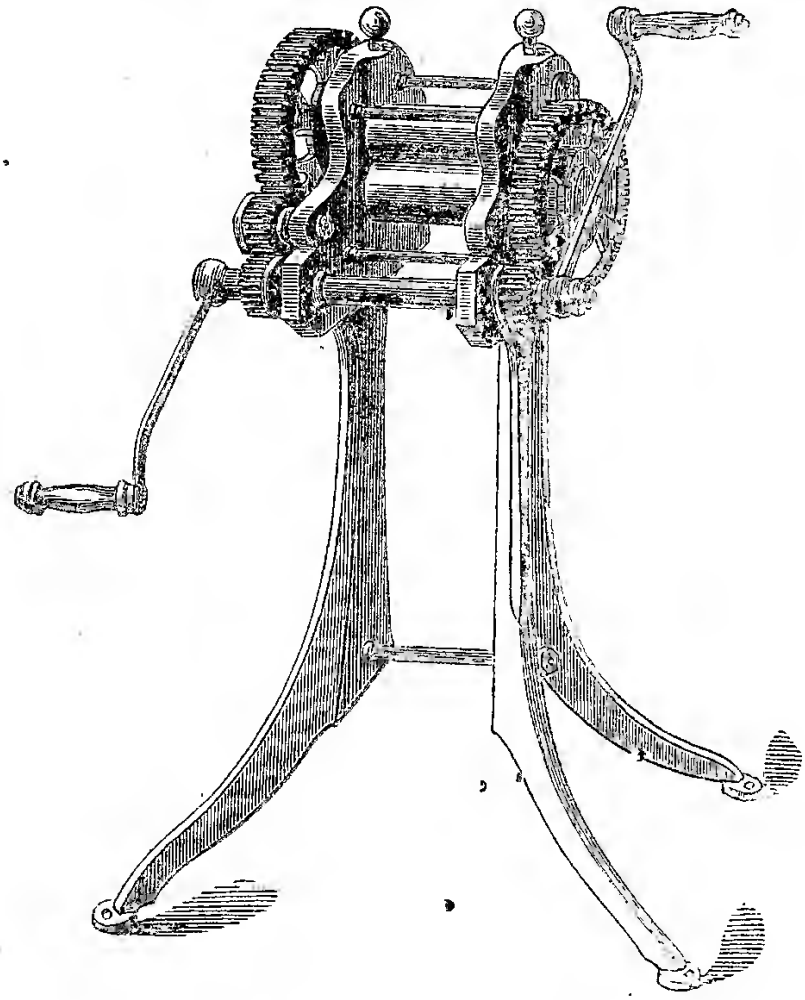


Fig. 25. Rollers for Gold.

best because it burns very slowly."* The gold is then filed, along its edges, and may be reduced somewhat in thickness at the anvil before taking to the "rollers" (Fig. 25). The metal should be

* Gee's "Practical Gold Worker."

introduced between the rollers, in the course of the rolling operation, in the same direction; unless when it is necessary to "cross" so as to accom-

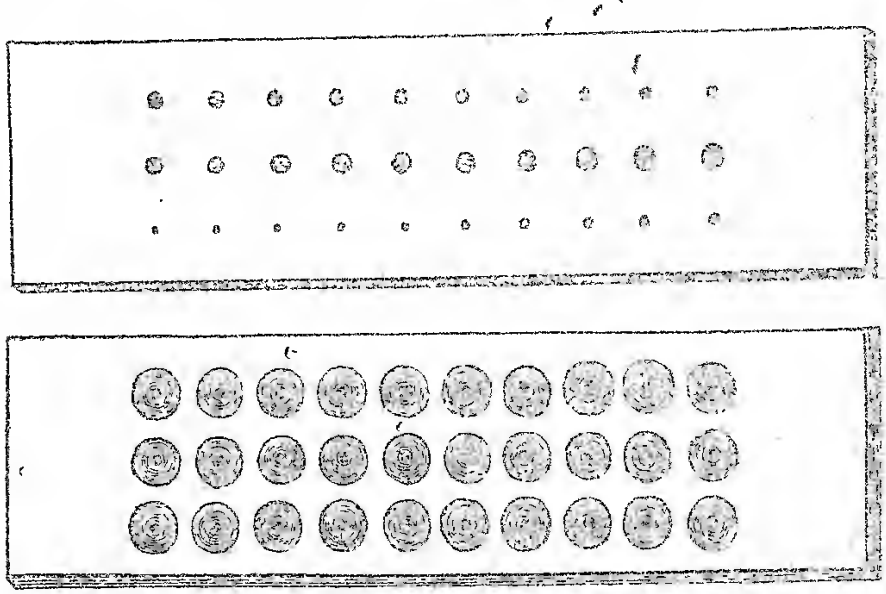


Fig. 26. Draw-plate for Wire.

modate the pattern lead, in which case the gold must first be annealed.

Clasp and wire gold is made of a mixture of gold, silver, copper, and sometimes platinum, or, without

Fig. 27. Drawing Tongs.

the platinum, more copper is used in the alloy than silver. The various receipts for this kind of gold are given at page 219.

To make *wire* the bar of gold is only slightly

reduced in the rollers, and from this thick plate strips are cut by means of strong shears fixed in the vice, the gold being held firmly in the grasp of strong pliers. *Before* and *after* cutting, the metal must be annealed. The strips are then—their edges having been slightly filed—hammered on a small bench anvil so as to give a certain amount of roundness to the strips, which is necessary before submitting them to the draw-plate (Fig. 26). They are then annealed, and one end must be filed to a suitable point, which, being introduced in the hole of the plate, comes through and affords a hold for the pliers or drawing tongs, by which the rest of the strip is drawn through. The draw-plates may be fixed in the vice where there is no draw-bench, and the point of the wire being grasped firmly in the drawing tongs (Fig. 27) a sudden pull or fall back of the body will draw it through. The wire should be kept oiled, and be occasionally annealed.

CHAPTER IV.

THE BLOWPIPE.—SOLDERING.

The Blowpipe.—The dentist may employ the simple mouth blowpipe for his soldering operations, or he may use one which receives its supply of air from a bellows, or a third, the hydrostatic blow-

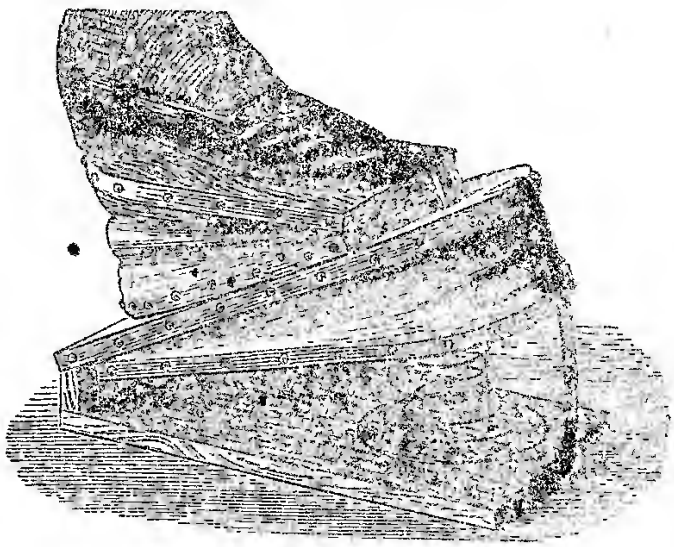


Fig. 28. Bellows for Blowpipe.

pipe, in which the inflow of water is made to expel the air contained in a tank or reservoir with such force as will give the blast required.

An ordinary bellows fixed to the floor, with an

elastic tube joining the nozzle of the bellows to the ordinary mouth blowpipe, with such slight modification as may be required for regular action by the foot, will serve as a bellows-blowpipe. More complicated machines may be purchased, however, and which, no doubt, act more satisfactorily, in which reservoirs are provided to equalise and maintain the stream of air.

A very simple form of hydrostatic machine is obtained in the following manner. One tank having been filled with water, another, made rather smaller, so as to fit easily into the first, is turned mouth downwards upon the water contained in tank No. 1. Thus the second tank is filled with air, which cannot escape except when a stopcock fixed in the top is opened. To this stopcock is fastened an elastic tube, the other end of which is attached to the blowpipe. To give force to the blast it is only necessary to add weights to the top of the tank containing the air.

Richardson thinks highly of the one represented by Fig. 29. It "consists of a tank or cylinder made of sheet iron, zinc, or copper, of variable dimensions, usually, however, from 4 to 6 feet in length and from 12 to 20 inches in diameter. To the side of the cylinder, near the bottom, a pipe with faucet is attached called the supply-pipe, and is designed to convey water to the tank, another is attached to the bottom, termed the waste-pipe, and is used to discharge the contained water. To the centre of the top of the cylinder is adjusted a stopcock to freely admit the ingress of air when the water is being discharged, without which the

sides of the cylinder would tend to collapse on the formation of a vacuum within. An india-rubber tube is also united to the top of the cylinder on one side, and is attached at its other end to an ordinary blowpipe or gas jet."

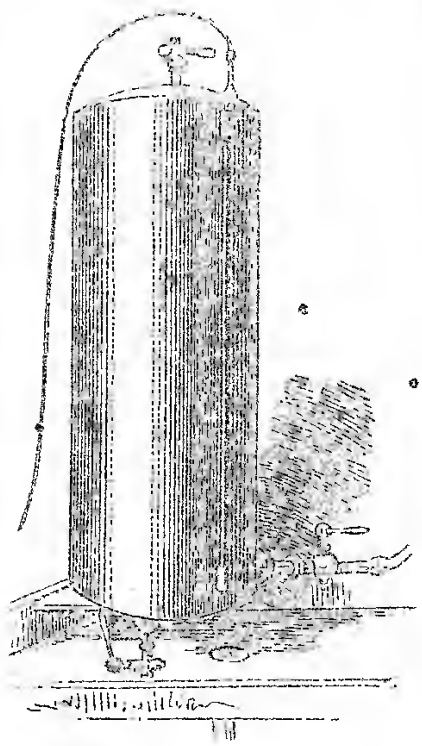


Fig. 29. Hydrostatic Machine for Blowpipe (Richardson's).

The simple mouth blowpipe (Fig. 30), however, is the one generally employed by dentists, and no other is really required in order to accomplish the *usual* soldering operations required for dental work. The flame by it can be regulated perhaps more readily and accurately than by any other means; and if the dentist does but take the little trouble required to learn the art of "keeping up the blast," even the longest soldering operations may be completed with perfect ease, and without that strain upon the chest which

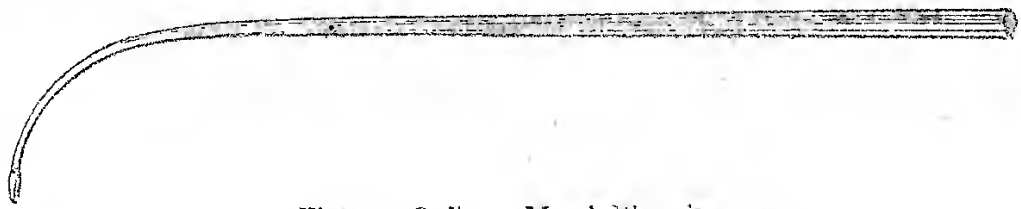


Fig. 30. Ordinary Mouth Blowpipe.

otherwise attends this work, and which has been the reason for most if not all having recourse to the machines referred to. The ability to maintain a

continuous blast is not difficult to acquire, as is often supposed; some come to it at the first or second trial, and *all* will overcome the difficulty after a few well-directed efforts.

"The art once learned," says Harris, "is never forgotten. But many will not master the first difficulty, and become the slaves to mechanical appliances which, however useful for many purposes, can never supply the place of the simplest and best of all blowpipes."

The following directions, given by an anonymous writer and quoted by Richardson, will point to the conditions required for maintaining the blast.

"The tongue must be applied to the roof of the mouth, so as to interrupt the communication between the passage of the nostrils and the mouth. The operator now fills his mouth with air, which is to be passed through the pipe by compressing the muscles of the cheek while he breathes through the nostrils, and uses the palate as a valve. When the mouth becomes nearly empty, it is replenished by the lungs in an instant, while the tongue is momentarily withdrawn from the roof of the mouth. The stream of air may be continued for a long time without the least fatigue or injury to the lungs. The easier way for the student to accustom himself to the use of the blowpipe is first to fill the mouth with air, and while the lips are kept firmly closed to breathe freely through the nostrils. Having effected this much, he may introduce the mouth-piece of the blowpipe between his lips. By inflating the cheeks and breathing through the

nostrils, he will soon learn to use the instrument without the least fatigue. The air is forced through the tube against the flame by the action of the muscles of the cheek, while he continues to breathe without interruption through the nostrils."

The bore of the point of the blowpipe should be of such a size as to admit a small knitting needle; and a disk or washer of bone or other substance may be fitted to the mouth end, so that the lips may rest *against* rather than close *over* the tube. The fatigue which overcomes the muscles, from keeping the lips closed over the tube, is the only inconvenience ever experienced when working for a length of time with the blowpipe, and this may in some measure be moderated in the way suggested.

Again, after soldering for some time moisture may collect in the tube and cause some annoyance when it is forced out at the nozzle along with the air. To prevent the escape of the moisture in this manner, a bulb or small globe of brass may be fixed in the pipe, about the middle of its smaller half. The moisture then travelling along the inside of the tube falls into this bulb, and is retained until the soldering is completed. Some of the blowpipes sold with the bulbs are not really made upon this principle, but the latter are merely soldered upon the plain blowpipe and have no communication with the interior of the tube. We have found this several times to be the case with blowpipes purchased from dealers in *watchmakers' materials*.

Soldering.—To solder successfully, the following points must be observed: 1st, the joints must be closely fitting; 2ndly, they must also be perfectly

clean; 3rdly, the flame requires to be directed and managed skilfully; 4thly, the solder should be well suited to the work it is used upon, and flow smoothly.

It is most essential to have the joints fitting close. Without this condition satisfactory results are impossible, and to obtain it care and skill must be employed. The second requirement is next in importance: the joints should be *clean*. To effect this, the parts to be soldered must first be scraped, to remove the oxidised surface of the gold, and then be covered with a solution of borax, in order that the surface may be *preserved* in a fit state for soldering. The borax solution is made by rubbing a lump of borax upon a slab of slate, or of rough ground glass, with water. In the solution thus made the pieces of solder are placed, and the joints are touched with the solution either by using a hair-pencil or a small piece of wood cut to a chisel edge—this last is most convenient in many cases. In soldering gold the borax solution must be very sparingly used; when it is used in excess and in a careless manner, it acts as a most effectual *barrier* to the running of the solder over the parts where it is desired. In soldering silver a liberal application of borax is necessary, and, after the case has been heated up to soldering point, the solder should be touched with a borax lump. Also in heating up the case after borax has been applied, the heat should be imparted *gradually* at first, otherwise the borax will swell and displace the solder. The third requirement is a careful management of the flame. Various *forms* and

shades of flame are obtained by means of the blowpipe. The former depend upon the position of the point in relation to the jet; the latter upon the force of the blast which is sent through the tube. With the point of the blowpipe held at a little distance from the jet a broad flame is obtained. If the blast be a strong one, the colour will be blue; if weak, white. With the point held just within the jet a pointed flame is obtained, the colour, as before, depending upon the force of the blast. Between these extremes we have others, in which the white and blue and broad and pointed are associated in various proportions. Of all these the most suitable for our purposes are the broad blue-white flame (mostly white) for heating up, and the pointed white flame for reducing the solder. The entirely blue flame should never be employed. As to the management of these flames, the rule should be to heat up the *plate* with the flame described, as if it were our design that the heat of the *plate* should melt the solder; when the solder from this action *begins* to give way, then the pointed white flame may be turned sharply upon it. The fourth point—that the solder should flow smoothly and freely—requires that the gold used for the soldering shall be of an inferior quality to, and therefore more fusible than, the plate to be soldered. At the same time it must be remembered that it is most desirable that there should be as little difference between the two golds as possible. Thus for 18-carat plate Richardson advises a solder 16-carat fine; then, supposing that the solder we use is as indicated about 2 or 3 carats

below the plate it is used upon, and that it has been well-mixed and melted, the smooth and satisfactory flowing of the solder altogether depends upon careful attention to the three *first* conditions to which we have referred.

CHAPTER V.

THE SWAGING OR "STRIKING UP" OF PLATES.—CLASPS.

THIS is, according to the model, a very simple operation, or the opposite. Most edentulous cases, and partial ones with shallow teeth standing, are very easily swaged between the zinc and lead models so as to fit the plaster cast; but lower partial models with long teeth standing over which the plate must be struck will be found sufficiently difficult.

Suppose the case in hand is an edentulous upper, belonging to the first class, and for which a gold plate is required. It is first of all necessary to have a line drawn upon the plaster model which will indicate how far the plate is intended to extend in all directions; sheet or pattern lead is then pressed over the model, and cut so as perfectly to represent the future plate, the traced line being the guide. The pattern is now taken from the plaster model, flattened carefully, and placed upon the gold plate, which may at once be cut by the bench shears according to the pattern, or a point may be used to trace the latter more exactly upon

the gold before cutting. Some advise that the gold should be left slightly larger than the pattern to allow for trimming and *slipping*. We think this is a mistake: the slight extension of the plate which results from the striking is amply sufficient to allow for trimming; and as regards the slipping, this is an evil which must be guarded against in a very different manner. The ragged edges which have been left by the shears are filed away, and the plate annealed by means of the blowpipe flame. When gold is heated to redness for this purpose, it may be cooled at once in water, since no rehardening takes place, as with steel, &c.

The first part of the swaging is now proceeded with; and it consists of beating the plate into shape upon the zinc, by means of horn, bone, or wooden hammers.* The plate is held by the fingers of the left hand in position upon the die, whilst the pointed end of the hammer is used upon that part of the plate covering the palate. Having got the palate to fit in a suitable manner, we next proceed to the alveolar ridge and the outer edges of the plate.

This part of the operation must be done very gradually and carefully in some edentulous cases which exhibit a tendency to "fold." This folding of the plate, which generally occurs in front, in a line with the frœnum, may be prevented by frequent annealing and persistent use of the mallet. In an exceptional case, however, it may be advisable to cut a narrow wedge-shaped piece out of the

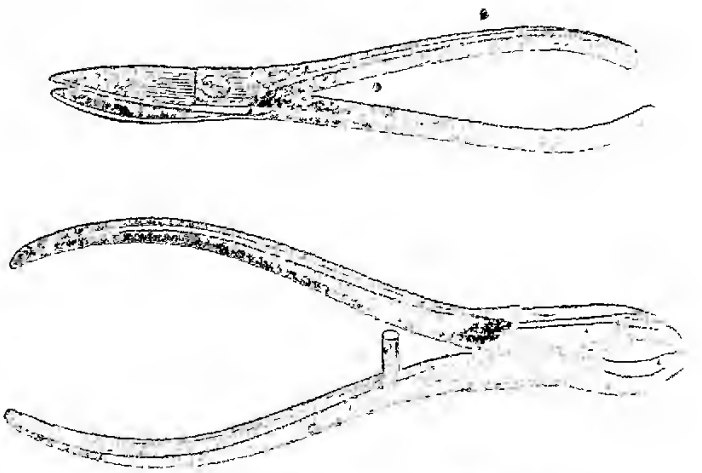
* Horn hammers of most convenient shape for this purpose may be had at the depôts.

front part of the plate; the edges close over each other as the striking proceeds. When the plate is fitted, these edges are dressed and soldered with the hardest solder (Ash's No. 1, for example).

During this and the subsequent fitting of the plate, particles of the zinc and lead adhere to the surface of the gold, which is in danger of being injured by their contact when it is heated, or annealed upon the charcoal. To prevent these metals from contaminating the gold, a layer of paper is sometimes placed between the zinc and gold, and between the latter and the lead when swaging. Oiling of the plate is also said to prevent the adhesion of the base metals; but we prefer to use the pickle acid for this purpose. This should be kept warm, and in some convenient place where the fumes may escape harmlessly. Before annealing, the plate is immersed in the warm acid, which at once clears it from the adhering metals. By this plan no time is wasted and all danger is avoided.

The plate having been sufficiently fitted by means of the mallets—during which process it should be more or less frequently annealed according to the peculiarities of the case—it is now placed between the die and counter upon the striking block or anvil. A sharp blow is then given upon the zinc with the swaging hammer, after which the plate is examined to see whether it is being struck into proper position; assured of this, it is replaced between counter and die and the striking proceeded with. When the plate has been struck into the shape of the first zinc, it is placed upon the plaster model—which in some simple

cases it may fit perfectly at this stage—and reduced to the proper dimensions. If there is much surplus, the best way to do this is to go round the plate with a marking point, tracing its outline upon the plaster model. Now take off the plate, and as there are two lines on the model—the outline of the plate as it should be, and the one just drawn, the outline as it *is*—the eye is at once afforded a reliable guide for this operation, which is performed by means of the shears (Fig. 31), punching pliers (Fig. 32), or



Figs. 31 and 32. Shears and Punching Pliers for Plate.

file. The plate, as has been said, may fit the plaster impression correctly at this stage; but the fitting is generally defective, and the striking must therefore be continued upon a second or even third die and counter. The usual practice is: for a model which presents no special difficulty, two dies and counters are provided; for the more difficult models, three dies and counters are made. Trouble is sometimes experienced from the splitting of the zinc die while swaging. If a thick washer or iron punch is interposed between the striking hammer and zinc, this

annoying accident is not likely to happen. The punch should be of such a height and shape that the left hand may grasp it while striking with the right.

It is by no means certain, however, that a correct fit will be obtained by using even the larger number of dies. For example, a suction upper plate, coming from the last and best die, does not accurately fit the plaster impression, but rests or grasps along its outer edges on both sides of the model, leaving the plate open along the line of the palate. This is owing to the contraction of the zinc: in reality, the plate has been struck to a model slightly smaller than the plaster one, so that when it is placed upon the latter it must ride or grasp upon the outer edges. To correct this defect the "fusible metal" models have been tried and recommended by some dentists; but these, as has been observed, have defects of their own which render their use objectionable. A more usual method for correcting the fault of the zinc die is to place one or more layers of damped paper along the outer surfaces of the zinc along which the plate grasps; the latter is then closed over these upon the die, and then struck between the die and the counter. But the most effectual and satisfactory method, according to our experience, is to take that part of the plate which grasps, between the fingers, and bend it out with a sharp decided motion of the thumb. The best way to hold the plate, so as to get the proper purchase and so as to see exactly what you are doing, must be ascertained before attempting to bend it. If it grasps upon a particular part or

point, rather than along a considerable length of its outer borders, we use pliers, and give the plate a sharp *pull* rather than a bend at the point where it rocks. An ordinary pair of pliers, in which the square jaws have been *rounded* away in such a manner as not to *mark* the plate, are most convenient. By one or other of these plans a misfit, which can be certainly attributed to the shrinkage of the zinc, may be rectified.

Suction Chambers.—A chamber may be made in a plate by swaging or by soldering. For the first it is necessary to fix on the palate of the plaster model, previous to sand moulding, a piece of wax or metal, which must exactly represent the height and extent of the desired chamber. This is, of course, reproduced in the zinc, and a corresponding chamber is made in the plate in the usual course of the swaging process. A sharper outline is given to the struck chamber by going round its edges with the steel or copper punch.

In order to solder a chamber an outline of the shape desired is drawn upon the plate. A hole is then pierced to allow an entrance for the small frame saw, which is made to cut out the part indicated. A piece of plate, of the form desired for the chamber, is next fitted, so as to cover the opening in the main plate, and to make a perfectly close joint with it. When this has been accomplished, the edges must be prepared in the usual way for soldering, and the chamber is then fastened in position by means of wire clamps (Fig. 33). These last are made of steel or iron wire—thickness of pin-wire generally—and are of different sizes.

Take a piece of wire about two inches long, bend it over the round pliers so that the ends shall meet upon each other, and a medium-sized clamp is formed. The case is then placed upon the charcoal and soldered. This will be very easily accomplished if the joint in the first instance has been made a perfectly close one. Small pieces of solder should be used.

Partial Plates.—These, if the teeth standing on the model be short, are very easily struck into shape; the pattern lead should be cut to the exact

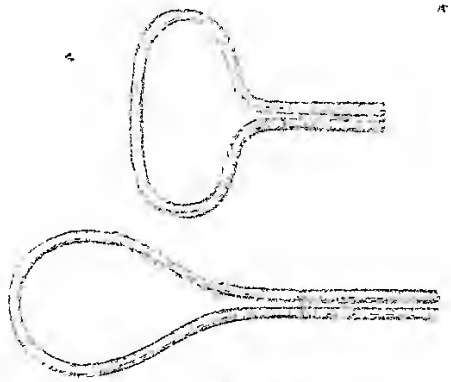


Fig. 13. Wire Clamps.

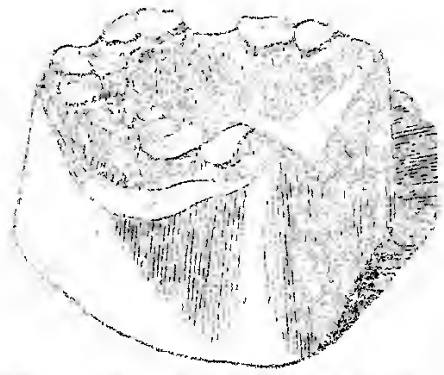


Fig. 14. Zinc Case with Teeth reduced to facilitate swaging.

size upon the plaster model, and the plate, if it has also been cut exactly to pattern, may be struck between the first zinc and lead, without filing down the teeth of the former, as it is necessary to do in the cases presently to be referred to. Many plates are rendered unnecessarily difficult to strike by leaving the pattern lead over three teeth—bicuspids and molars—which are subsequently to be clasped. In all such cases the pattern should be cut so as to fit accurately round the necks only of these teeth. Those models on which bicuspids

and molars of considerable length are standing, to the top of which the gold plate must be struck, are sometimes difficult to strike to; and it is in these that we find the tendency to "slip" during the swaging process. It is found advisable in such cases to reduce the teeth of the first zinc to within about an eighth of an inch of the gum (Fig. 34). Otherwise, with long teeth standing the mallet could only be made to fit the plate to the model in a very imperfect manner, and if the former were struck in such a condition between the die and counter it would split in all directions; but with the teeth shortened to the extent mentioned, the plate can be very readily struck into shape. Instead of filing them down upon the zinc model—a somewhat laborious exercise in certain cases—the impressions of the teeth in the sand may be *filled* to the extent required. The surfaces in either case must be solid, smooth and rounded at the edges. The pattern for the plate may be cut upon the plaster cast as usual; but it will often be found most convenient to fit it to the reduced zinc cast, leaving it "full" over the surfaces of the filed teeth, so as to allow sufficient material for striking to the height required. The plate, cut from the pattern is then fitted in the usual manner with the mallet and afterwards at the block upon the first or filed zinc. It is then placed upon the second zinc, and forced into shape by the mallet and bone punches; more or less frequent annealing being necessary to prevent splitting. It may now be struck at the block: but here it is necessary to observe certain precautions which shall prevent its slipping. This is a

difficulty frequently met with in lower partial plates or bridges. In such cases it is designed to fit to the top of the long teeth behind which it passes; but, after striking between the second die and counter, the plate is found to have slipped down from the position upon these teeth which it should occupy.

This is the result of the manner in which it was placed between die and counter; for if the plate and die be struck into the resisting lead, both are not sent *home* together, but the plate is held back by the lead while the zinc passes by itself down to its proper seat. If the simple precaution be taken of placing the plate in the *lead* before striking, instead of upon the zinc, "slipping" will never be encountered. But it is not sufficient to place it loosely in the lead and then close the zinc upon it and strike. Care must be taken that it is placed sufficiently *deep* in the lead counter before striking. To accomplish this in some instances it will be necessary to use the horn hammer, and even the round-edged pliers; the more difficulty there is experienced in doing this, the more reason is there for taking the trouble. Through the whole process of "striking" the same manner of placing must be observed, for the friction between the plate and lead, when the former is driven down with the die, has a constant tendency—even when the counter has been widened by repeated striking—to draw it down from the teeth.

If it is intended to have the plate "punched" round the standing teeth, that should be done upon the second zinc. The copper or small bone punch may be first used. It will fit the plate sharply to

the necks of the teeth, and so indicate the line to be followed by the steel punch. The latter (Fig. 35) must then be used with great steadiness, keeping it in constant and regular motion along the line required. The plate then, if accurately fitting the plaster model, is prepared for the "clasps."

Fig. 35. Steel Punch for chasing.

Clasps.—Partial cases are generally supported in the mouth by means of clasps. These may be formed from gold plate, or from gold wire.

The "plate clasps" are the most satisfactory which can be employed for the great majority of cases. The objections to the use of the "wire clasps" are that they are ineffective as a fastening, and destructive in their action upon the natural teeth round which they are placed. They are ineffective because, first, they are too narrow to give a steady support to the case; and, second, they act upon that part of a tooth which is not well adapted for the purpose of holding—viz. the neck. Then the wires are destructive, because, being narrow, and acting along the line of the tooth least protected by enamel, they act rapidly as an abrading power, cutting into the substance of the tooth sometimes to a considerable depth.

The effective support obtained by plate clasps may be best observed and contrasted with those made of wire in the case of a narrow-necked bicuspid or canine tooth.

Suppose a wire clasp is fitted for the tooth figured; when the case is finished and about to be placed in the mouth the dentist bends the wire to the small circumference at *b*, and the theory is that the wire will stretch sufficiently to pass over the thick part of the tooth at *a*, and reclose and grasp again the small neck when it passes to *b*. In practice this does not happen; if the wire has lost its elasticity in soldering the flat teeth, it closes but little, if any, after passing *a*, and a wire retaining the best possible spring is still unable to close upon the narrow neck of a large-crowned tooth. The second figure shows a plate clasp fitted to the same tooth; as the denture to which it is attached is pressed "home," the clasp continues to act upon *a*—the broadest part of the tooth—which it does not pass, and therefore continues to grasp in a perfectly satisfactory manner.

Fig. 36. Bicuspid Tooth showing the ineffective action of a wire clasp.

The points which must be observed in order to obtain the best results from this method of clasping are elasticity, shape, and disposition. First, the clasp should grasp the tooth by its elasticity, and as this quality depends—other things being equal—upon the thickness of the plate used, the latter must be as thin as the other circumstances of the case will allow. Those other circumstances upon which this thickness of the plate must depend are the breadth and the length of the proposed clasp. For example, a very long bicuspid or molar must be fitted with one made of

Fig. 37. Bicuspid Tooth fitted with plate clasp.

thinner plate than would be used for a much shorter tooth, and by thus varying the thickness we obtain an equal spring or elasticity for the two clasps.

Again, the length of the spring must also be considered; for instance, a clasp made to surround a molar of large diameter will require to be thicker than would be the case if a short one acting only upon the *side* of the molar was employed. In connection with the elasticity of plate clasps it must be remembered that this also depends upon the way in which they are soldered, and, though otherwise perfect, the satisfactory action of a clasp may be rendered impossible by the careless performance of this operation. A short one, for example, acting only upon the *side* of a bicuspid, must be soldered *only* at the back part of the clasp, thus leaving the whole side perfectly free as a spring. A long clasp extending round the face of a molar, on the other hand, should be soldered right round the back and side as well, thus leaving only that part free which covers the face of the tooth.

But besides varying the thickness of the plate and the disposal of the solder, according to the peculiarities of the clasps, in order to have them uniformly elastic, we must vary the thickness also, in order to accommodate the *condition* of the teeth as found in different mouths. For instance, in the case of particularly large and firmly fixed teeth, we must use somewhat thicker plate than usual, whereas in the case of teeth which are slightly loose, plate must be used which is particularly thin; and if this precaution be taken, observing also what has

been said in regard to soldering, these clasps will act in a most satisfactory manner in the latter case. The shape of a clasp must of course correspond to the shape of the tooth round which it is to act; a canine tooth requires, for example, that its clasp should be low at the back, and rise to a high peak on each side; while upon molars and bicuspids the clasps may be kept at an almost perfectly regular height all round. This kind of fastening, it may generally be said, should rise as high at all points as the thickest and most prominent parts of the wall of the tooth which it surrounds and acts upon. Canine teeth are well adapted for clasping if the "bat's-wing," or side clasp, be used.

Fig. 38. Canine Tooth fitted with plate clasp.

The accompanying figure shows one side of a canine tooth fitted with this description of clasp; it is rounded off at *a*—the neck of the tooth, which gives no holding surface—but it is carried full up to *b*, which is the widest part of the canine, and which gives a most effective hold.

Fig. 30. Bicuspid Tooth fitted with plate clasp.

A bicuspid clasp, acting along both *sides* of the tooth, acts most satisfactorily.

The usual shape of such a fastening as it fits against the side of the bicuspid is shown in the figure.

The advantages of these side clasps are that they act most efficiently, and they do not "show;" indeed, it may be said that their efficiency depends upon their not showing, for if they were carried

round upon the face of the tooth they would not act so well. Lying, as they do, against the sides of the natural teeth, the artificial ones may be fitted over the front border of the clasp so as to perfectly conceal it.

For the molar teeth no very uniform rule can be given. In the case of canines and bicuspids the sides are almost invariably the only holding surfaces, but the molars afford a good holding surface in all directions; and the fitting of a clasp round the face of teeth placed so far back in the mouth is not so objectionable on the score of appearance as with the others. The molar clasp, therefore, is sometimes made entirely to surround the tooth, sometimes it acts only at the side, and oftenest, perhaps, it occupies a middle position between these two. Their length depends upon the conditions of each case; as regards their shape or breadth, the same rule applies as for the bicuspids. In the case of a molar such as that sketched in Fig. 40 the clasp may rise high up on the side of the tooth as at *c c*; but round the face at *a*, and the back at *b*, it will be observed from the shape that the clasp should not rise higher than the points indicated.

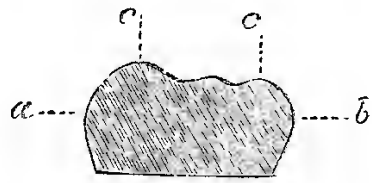


Fig. 40. Molar Tooth showing the height to which the Clasp may be made.

Arrangement or Disposition of Clasps.—This is a very important point, for without a correct adjustment or arrangement, so that they will act against each other and against themselves, the most perfectly shaped clasps will be useless.

Having decided in any given case as to which teeth are most suitable for clasping, it must next be considered how a proposed clasp will act when tightened; that is, in which direction will it tend to draw the plate? When this has been ascertained, another must then be provided which directly opposes this tendency by pulling in an opposite direction; then, so far as these two are concerned, the arrangement is perfect. A double bicuspid clasp, which closes upon both *sides* of the tooth, is a perfect arrangement. Here, if the clasp be tightened on one side of the tooth, its tendency is directly resisted by the opposite one, and the plate remains fixed in its true position. Again, if a clasp be carried round from the back part of a molar, covering the posterior half of its wall, and another round the front of a bicuspid on the same side of the mouth, these together would form a perfect arrangement. But suppose the same back-acting molar clasp was used with one similarly fitted round the *back* of the bicuspid instead of round the front, such an arrangement would result in failure, for both clasps would draw in the same direction and unsettle instead of fasten the plate.

We are not, however, always able to resist the action of one clasp by that of another in the way described. How shall a plate carrying bicuspids and molars be fastened, where only the front six natural teeth are standing, with no space between laterals and canines? This is one of those exceptional cases where the "side clips" are useless; for there is no clasp or point to resist their action, and a plate fitted with them would simply be un-

settled, and would fall back into the mouth in the direction of the arrow, Fig. 41, if they were closed. The clasps in such a case must be fitted completely round the *face* of the canines in the shape of a narrow band near the gum, as traced by the dotted line *a b*; and they must be soldered round the back and *side* of the tooth, so that the only acting part shall be the narrow band in front. Then the latter when tightened will be resisted by the gold at the back.

Again, where only one or two natural molars remain on each side of the mouth, a clasp fitted round the front of the molars *only* will incline to unsettle the case and force it out of the mouth. In these cases, supposing the second and third molars to stand together on both sides of the mouth, then a clasp should be carried round the back of the third molar to resist the tendency of the one fitted round the front of the second. Fig. 42 shows a case of this kind. Here if clasps were fitted only round the front of the molar and bicuspid at *a*, the case would not *sit* satisfactorily, therefore we carry clasps round behind the molar to *b*. As the third molar is generally very short a wire clasp may be used. Where this back clasp *cannot* be applied, then the one round the front of the second molar should encircle that tooth back and front as far as possible, and it should be soldered (as in the last

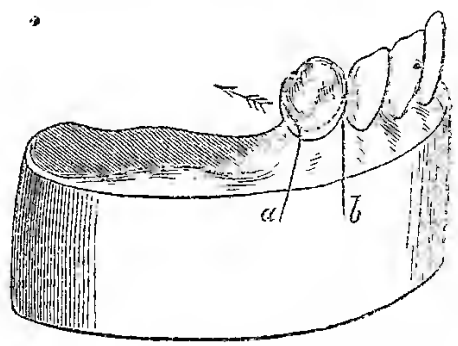


Fig. 41. Model, with Plate, showing the action of Clasps.

case) round both back and side, so that the band covering the face shall act against that at the back of the tooth.

Wherever it happens that a finished plate, ascertained to be itself a good fit, begins to spring out of position when the clasps are tightened, it may be concluded that either the latter have been badly arranged or that they have been tightened in an injudicious manner. In the latter case they should all of them be opened until the plate fits steadily

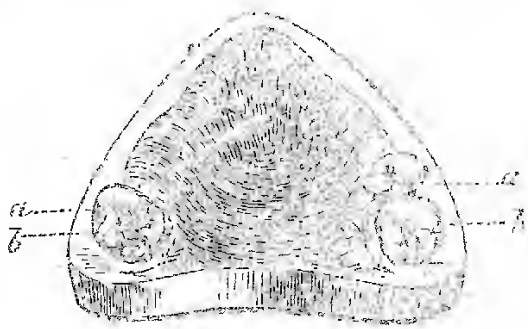


Fig. 42. Model showing how Clasps should be placed.

again, when the reclosing must be done with particular care.

Fitting the Clasps to the Teeth and Plate.—It is necessary first to take a pattern in lead-foil. The foil must be pressed accurately into the shape of the tooth, and then cut carefully to the exact size of the desired clasp. If the pattern has been accurately fitted to the tooth and the gold band cut exactly to the dimensions of the lead, little difficulty will be experienced usually in bending the gold into the shape of the tooth. In cases of special difficulty, it may be advisable when a fair fit has been obtained

with the pliers to place the clasp between the lead and zinc and strike it into shape. The impression of the tooth in the counter should be slightly enlarged with a grower, and the clasp inserted into it (the lead) instead of upon the zinc before striking, in the manner already described for preventing the slipping of plates.

When the clasp has been fitted and "dressed," the main plate is then filed just sufficient at the neck of the tooth to allow the clasp to pass down into position between the main plate and the natural tooth. In the case of long molar clasps, or others intended to act only upon the front of the tooth, the joint should be made close round the back and *sides;* but for short side "clips" the joint should be close along the short line at the back, where *only* the solder is to run, and from this point forward along both sides the main plate may be made to taper away neatly from the clasp to a slight extent. This will give a more finished outline to the plate, and also leave free working room for the band. The joints should now be scraped, and the clasp united to the plate with wax cement; the latter will hold more securely if the parts be slightly heated before applying it. The plate with clasp attached is now carefully taken from the model, and its lower or palate surface imbedded in equal parts of plaster and sand, made into a paste with water.* When this has set, the wax is removed from the joints, which must then be thoroughly cleansed and prepared for soldering. The case is then heated, in order to dry the plaster.

* See p. 256.

This must be done slowly at first, or the parts will spring asunder. When dry, it is placed upon the charcoal and soldered, or a preliminary heating may be given in the fire or stove. The pieces of solder should be small for this work, and should be placed upon the joint and leaning against the clasp. There is no difficulty about the soldering if the joint is closely fitted and clean.

The plate is then disengaged from the investient, cleaned in the pickle-acid—if it is to be tried in the mouth at this stage—and after washing thoroughly, it is ready to receive the biting blocks.

Strengthened Plates.—Nearly all lower plates require to be strengthened by soldering a second plate to the first, and the same operation is sometimes necessary with upper plates also.

In such cases the first point to be decided is whether the second or strengthening plate should be soldered on the inside or on the outside of the first or main plate. This should entirely depend upon the relative sizes of the plates. A strengthener nearly as large as the main plate should be soldered on the outside or lingual surface of the other. A narrow strengthener, on the other hand, should be soldered on the inside or palate surface of the main plate; for if a large strengthener were soldered on the inner surface an unsteady fit would probably be the result—the plate would rock upon the strengthener. This result is of course most noticeable in an upper case. With narrow strengtheners there is not the same tendency, for in the striking they get readily sunk in the main plate, and for the sake of appearance these may be soldered on

the inside or palate surface. Before cutting the pattern in lead for the second or strengthening plate, the other should be tested and its weakest points ascertained, for over these the strengthener must be left broader than elsewhere. When a partial plate is strengthened it will often be advisable to carry a tongue of the strengthener into the spaces where one or two artificial teeth will stand isolated. This is more especially required in the case of tube teeth—in these the pin should be soldered through both plates; it is also necessary in cases where the teeth are long.

The plate from which the strengthener is made is usually thinner than the principal one; how much thinner depends of course upon the peculiarities of the case. Narrow lower plates require stronger strengtheners than upper ones do.

The strengthener, having been struck into position and fit between the metal models in the usual manner, is then placed in position upon the main plate, and both are struck together between the die and counter. They are then scraped over the surfaces to be united, and the borax solution sparingly applied; the two are now grasped at different points by the wire clamps, which hold them securely together during the soldering operation. It is best to only partially solder them in the first instance, or "tack," as it is called; that is, three or four small pieces of solder are melted at considerable intervals round the joint; the case is then examined, and if the edges are closely fitting, the soldering is at once completed. To do this satisfactorily, the solder should be used in narrow

pieces, and placed along that line of joint only which stands highest as the case lies upon the charcoal, as indicated by the arrows, Fig. 43. Now when the plates are heated and the solder flows down between them, and appears along the lower line of joint, we know that it must have traversed the entire surfaces of the plates to be joined, and may therefore consider the union to be complete. When the solder can be clearly traced in a continuous line round the plates, the sharp edges may be reduced with the file, and

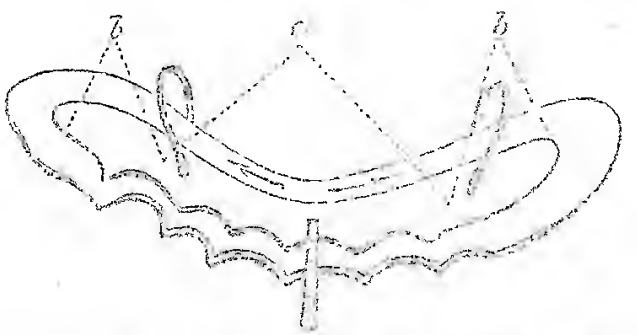


Fig. 43. Lower Plate and Strengthener, clamped and ready for soldering.

the clamps having been replaced, more solder may be added for the purpose, if necessary, of flushing the joints. The flame required for this work is the broad blue-white flame throughout.

If, however, after "tacking" the plates we find that the edges are not sufficiently close, they must be again struck at the anvil, where but little force is required to complete the fitting. The soldering is then proceeded with as described. From the point where the two plates are "tacked" until the operation is completed they should not be placed

in the cleaning acid, as it leaves a surface between the plates unfavourable for soldering; the base metals which may adhere after striking should therefore be removed with the scratch-brush. Striking the plate after the soldering has been completed has a tendency to "start" the solder; it should therefore be avoided if possible. In the after stages of working, if it be necessary to heat up the plate again as in soldering clasps, pins for tube teeth, &c., the *clamps should be replaced*. Some trouble may be experienced in these after heatings from the solder of the joined plates melting. This may be entirely prevented if a strong solution of borax be liberally applied round the whole joint, and vitrified by heating up the plates, using the blue flame to melt the borax. Of course strong wire clamps must grip the plates while this is being done. By this means a thin coating of glass is given to the whole surface of solder, which is thus thoroughly protected and preserved unaltered all through the construction of the plate. The strengthener should, as a rule, be soldered before attaching the "clasps;" and the solder used should be higher in quality than that used for subsequent operations. With 18-carat gold for the plates and 16-carat (Ash's band) for the clasps, we have always used No. 1 solder for the strengthener, and No. 2 for clasps, &c.

CHAPTER VI.

TAKING THE "BITE" IN WAX AND PLASTER.

In small partial cases it is usual simply to take an impression of the opposing teeth; and the operator, having observed the manner in which the patient naturally closes the mouth, is able, when the model of the opposite teeth is made in plaster, to join it with the other in the correct manner. In most of these cases there are sufficient indications on the cusps of the teeth to show how the models should be joined to represent the natural bite.

With large upper and lower cases, however, a different method is adopted. Wax is softened and formed into a block round the ridge of the plate. It must be of such a height and shape as will take the impression of the teeth of the opposite jaw when the mouth is closed in a natural manner. In the case of an edentulous upper, or of a complete set of upper and lower, we have no guide on the model, as with partial pieces, as to the height and fulness required for the biting blocks. In such cases the wax must be formed along the ridge of the plate, according to such indications of the required height as may in the first instance have

been obtained from the mouth itself. And it is well to leave the blocks somewhat in excess, both as to height and fulness, so that upon trying them in the mouth they can be cut down to what may be taken as the natural depth of the bite, and may also be reduced in front to that shape which gives the best expression to the face. Both these conditions will more readily be obtained by reducing than by building up the wax. If the precaution be taken of heating the plate just sufficient to melt the surface of the wax when *placing* the blocks, the latter will remain perfectly fastened during the subsequent stages.

Getting the patient to bite correctly is a well-known difficulty. Dentists of experience say that a wrong idea is conveyed to the mind of the patient when he is told to "bite;" this seems to suggest that a point to point closure of the teeth is desired. The expression "close the mouth," or "bring the side teeth together," may therefore induce a more natural articulation. Again, the patient may be asked to "swallow," and that movement almost *compels* a natural closure. Perhaps the most valuable suggestion, however, is that which points to the tactics of the painter who draws the attention of the sitter away from the object of his visit by conversing upon other subjects, in order to obtain the natural expression he desires. False bites are no doubt often the result of the patient's anxiety over an operation upon which so much seems to depend.

When the wax blocks for an upper and lower set have been reduced to the depth and fulness

most natural for the case in hand, and when the operator is satisfied that he has discovered the natural bite of the patient, the latter must be made to keep the mouth closed in that manner while a line is drawn down the face of the block to indicate the centre of the mouth, and others are cut across the joints at opposite points, to serve as guides for accurately rejoining the blocks in the work-room.

Casting the Bite.—The simplest method, and one very often employed, of casting bites is the following. The plates (supposing the case to be a complete set) are put on the plaster models, and the wax blocks—which should be perfectly dry—are joined exactly in the position indicated by the cross cuts; and the parts—models, plates, and blocks—may then be fixed with the wax cement. Plaster is now mixed and shaped on the bench to the form of a square slab, and the ends or backs of the models are imbedded in the thick plaster slab. The backs of both models should be oiled before imbedding them. When the plaster is hard the models may be withdrawn from the slab, and the setting of the teeth at once proceeded with. Or the bite may be cast in this way. The backs of both models are cut in rough dove-tail fashion, so as to give a good hold to added plaster. Then one of the models is placed flat on the bench, and plaster added to

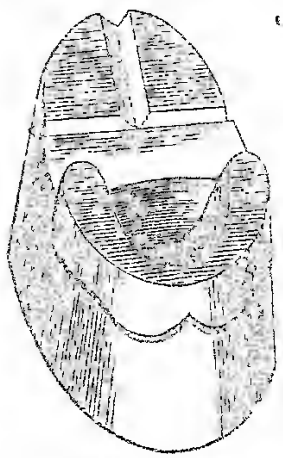


Fig. 44. Model with added Block for Bite.

this roughened surface, building it in the shape of a flat block to the back of the model. The surface of this plaster must receive one or more grooves (Fig. 44) or cuts, made so as to allow the parting of that which is to be filled into them. The blocks, plates, and models are united as before, and the grooves of the added block having been oiled, plaster is mixed rather thick, filled into the grooves, and built up (Fig. 45) to the roughened back of the other model. When plaster is to be united, as here,

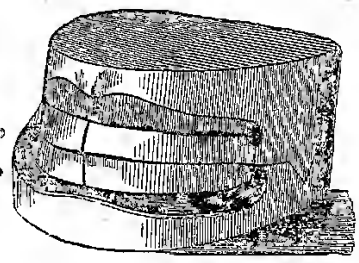


Fig. 45. Model with Bite cast.

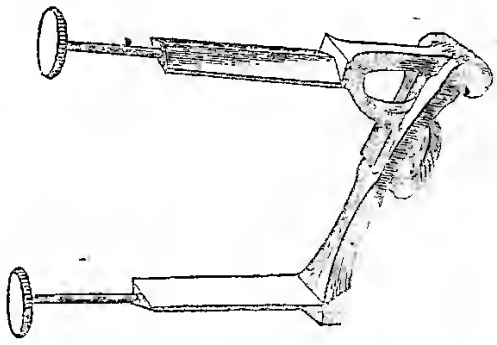


Fig. 46. Articulating Frame (Graham and Wood's).

to a roughened surface, that surface should be moistened in order to effect a secure union.

Another kind of working bite—the best of all—is obtained by using an articulating frame. The simplest form of this implement acts on a single joint (Fig. 46); and if this joint be well made, the simple articulator answers the purpose well. They are made of brass or gun-metal, and in a variety of shapes, as may be seen in the catalogues. The base or bottom of each model is roughened, and the parts (biting blocks and models) fastened in position with cement; plaster

is then mixed and added to the roughened surfaces of the models, and the arms or suspenders of the articulating frame—which have been previously oiled—are closed upon the added plaster, and imbedded and covered over by it (Fig. 47). Other forms of articulators are made with joints which permit movement in every direction. These are no doubt useful where a *false* bite has been obtained from the patient; for, a correct one having been afterwards obtained, it is not necessary to recast in plaster as with a simple articulator, but by simply accommodating the screws to the new "bite," the change required is at once accomplished, the screws being retightened to preserve the new articulation.

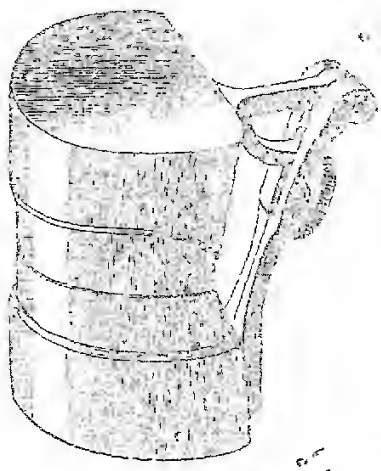


Fig. 47. Bite cast to Articulating Frame.

An articulator of this description has been introduced by Mr. Davidson, which seems perfect in every way; and it has this advantage, that the suspenders may be imbedded in the plaster while casting the impression as taken from the mouth; afterwards, when the bite is obtained, the joints are accommodated to it, and fixed in position by means of the screw. Many of the advantages obtained by working with an articulator are well explained by Mr. Davidson, but a very important one may be added, viz. that we are enabled by this means to see the inside range of the teeth, and we can thus readily provide a perfect articulation of

their grinding surfaces. By the other bites we cannot see the inside cusps, and we can only be assured that the articulation is good as regards them by a somewhat troublesome process, which is therefore often neglected.

Bites for partial cases may be cast by first cutting a perpendicular groove on the back of the model, then filling plaster into the impression of the teeth in the wax block, also into the groove on the model, and joining the plaster as you would build a bridge. The groove and all parts of the model likely to be touched by the plaster should of course be oiled.

In the case of edentulous or nearly edentulous uppers or lowers, it is of great advantage to take a *full* impression of the opposite jaw; when this is cast and separated, its teeth are closed into the impressions made in the biting block, and the bite cast as described for complete sets. The advantage of having this model of the opposite jaw is that you are at once provided with a guide as to the character and disposition of the teeth required for the case. In small partial pieces the adjoining teeth are sufficient guide; but in an edentulous upper, for example, the only guide we can have is a complete impression of the lower teeth. When this is before us we can tell by *their* length, projection, and form what is required for the upper set.

Where there are few opportunities of trying cases into the mouth, and where the dentist, having taken model and bite, leaves the construction of the set entirely to his assistant, the above system should be invariably practised.

CHAPTER VII.

SETTING OF MINERAL TEETH ON GOLD PLATES.—SWIVELS.

Flat Teeth.—Where the teeth of a set or a partial set are to be fitted entirely upon the plate—as when supplying front teeth where the gum has fallen away after the extraction of the roots, or as with bicuspids and molars, which, not occupying a conspicuous position in the mouth, are generally fitted in this manner—the fitting is easily accomplished. In most partial cases, however, and in many complete sets, the teeth are required to fit the *gum*; and to effect this it requires some skill, for while the front part of the base of the tooth must fit accurately to the gum, the back part must fit accurately to the plate. The first point, then, is that the latter must be cut along its gum border so as to lie *within* the line along which the teeth are to be fitted to the gum. It is usual in such cases to cut the plate—guided by the eye only—to what upon comparing the bite with the shape of the gum seems necessary. Then one of the central teeth is ground at the lathe (Fig. 48), until the proper length and position as indicated by bite,

&c., is obtained, and so on with the others. But it is impossible in the first instance to cut the plate by the eye, so as to give it exactly the outline and position required. So that we find as the fitting of the teeth proceeds it is frequently necessary to interrupt the work in order to accommodate the plate piece-meal to the more correct outline as indicated by the advancing tooth. This is a tedious method, resulting occasionally in awkward mistakes, frequently in rough, imperfect fitting, and always in loss of time. The plan we have adopted and long practised is the following.

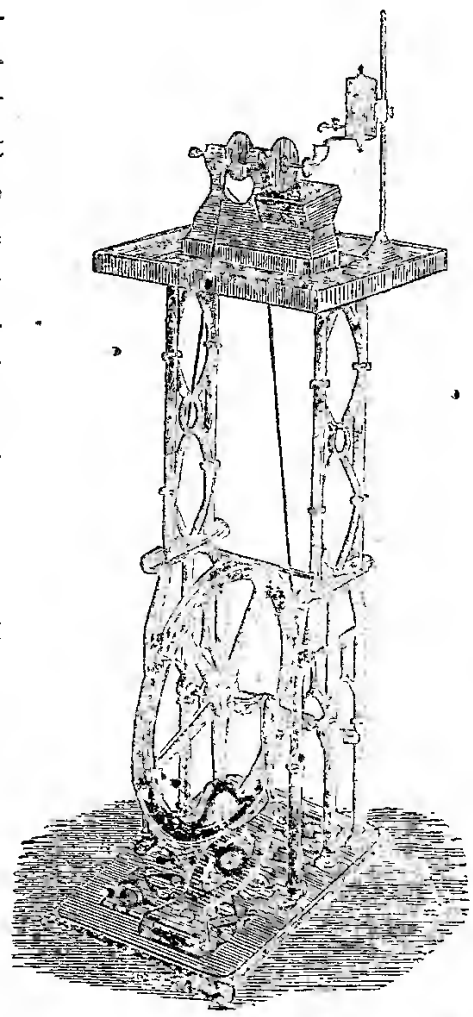


Fig. 48. Lathe for grinding Mineral Teeth

Fit the teeth at first by themselves to the model without the complication of the plate. Colour the plaster gum with rose pink, and fit the teeth accurately to it, to the proper length and position as indicated by the centre line, bite, &c. This is a very simple operation, for the plate not being on the model there is no complication, and the atten-

tion is not divided. As each tooth is fitted it is secured to the model behind with cement. When all are thus fitted and secured, go round the fitting edges with a fine needle point, leaving on the plaster gum a traced line exactly representing the position of the fitting teeth, also draw straight lines from between the teeth out upon the model. Upon removing the teeth and the wax, it will be at once seen (Fig. 49) that we have unerring guides for cutting the plate at one operation. It must be cut so that its gum border shall lie about an eighth of an inch within the festooned line. Putting the plate on the model, the straight lines drawn from between the teeth at once show—however much surplus plate there may be—the points where the deep cuts are to be made. As these are made on the plate, the traced line on the plaster shows itself, and by it the complete reduction is accurately and quickly accomplished. Now matters stand thus: the teeth are perfectly fitted to the gum over the front half of their base, and the mind pencils off that part as not to be touched again by the corundum wheel; all that is required now is to colour the edge of the plate, and grind carefully from the back part of the base of the teeth the little that is necessary to permit them to settle down to their traced marks on the gum.

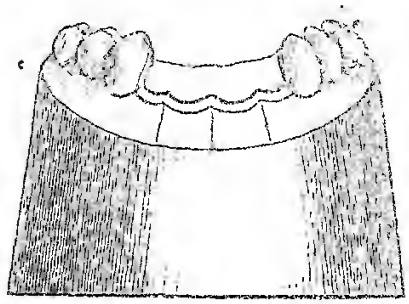


Fig. 49. Model with Traced Lines, showing the best method of fitting teeth to plate and gum.

The advantages of this method are best observed

where the clasps form a further complication; also in those cases of large uppers with irregular gums where there is an uncertainty as to which teeth should fit the gum and which the plate. In such cases this point can be at once settled satisfactorily when they have been fitted as described and the effect observed. The teeth may be backed either before or after their second fitting.

Backing Flat Teeth.—They must first be cleansed from the wax adhering to them, and their pins straightened or made parallel to each other. The ends of the pins of each tooth are then tipped with colour, and a strip of plate is laid steadily against

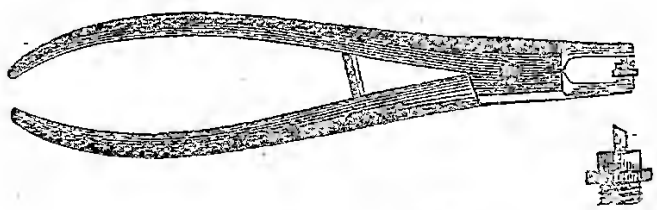


Fig. 50. Perforating Pliers.

them. The colour marks thus left on the gold indicate where the holes are to be punched by means of the pliers represented by Fig. 50. Fig. 51 shows a perforating tool introduced by Dr. Mallet, by which both holes may be punched at once, one of the perforators being movable, so that it can be adapted to any distance from the other which the positions of the pins of the various teeth may require. The strip of plate is then placed upon the tooth, and the outline of the required back taken; the latter is then cut, dressed with the file, and fastened to the tooth. This last may be effected by riveting the pins or by splitting them.

Riveting is best done upon a lead block—a counter for example—and the surface upon which the face of the tooth is laid must be clean and flat, or *very slightly* concave. The pins are cut to such a height only above the back as will ensure a good rivet head. Tight riveting must not be practised; there is no necessity for this, since the solder *fixes* them to the back, and a tightly riveted tooth when put through the fire is liable to *crack*, owing to the expansion produced by heat. Backs may also be fastened sufficiently by splitting the

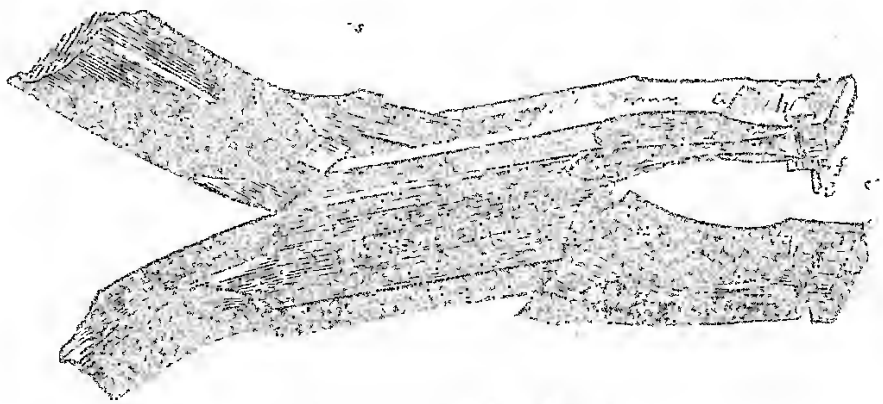


Fig. 51. Perforating Pliers (Dr. Mallet's).

platinum pins, and we think this to be the preferable method. A rivet head may sometimes be run over by the solder without the latter taking effectual hold of it, thus leaving the tooth apparently soldered, but really depending altogether upon the rivets. This is scarcely possible when the other plan is adopted. The pins having been cut almost flush with the back, the holes in which should be slightly countersunk, are split with a small square edged tool. The cut must be made across the middle of each pin, and only to the depth of the

countersink. A careless split made with a graver breaks up the platinum and leaves the pins without strength. The teeth—which are now supposed to fit accurately in all respects to the plate and gum—are replaced in position and fastened to the plate with the cement. The case is now ready for inserting into the investing mixture. This is made by combining plaster with either sand, pumice, or asbestos. Or sometimes plaster forms the one part, while equal parts of sand and asbestos form the other. The asbestos serves to bind the mixture, so that if it be not used one or two threads of iron binding wire should be formed into a skeleton frame to be imbedded in the plaster surrounding the teeth. This may be formed so that one thread will lie under while the other goes round the face of the teeth, at about one or two eighths from their surface. The substances used are mixed moderately thick with water, and poured into suitable shape upon paper laid on the bench; and the plate is imbedded so as to cover its lower or palate surface, bringing the material up in front of and enclosing the cutting points of the teeth. If the wire be used as a binding frame it must be imbedded at this stage. It is of importance that there should be as small a quantity of investing material about the plate as possible—this is a point which has a direct bearing upon the warping of plates—in the case of broad uppers, therefore, the palatal surface should be left to a great extent uncovered by it. In front of and under the teeth the mixture may be from two to three eighths thick. In partial cases the investient must be kept at its full

strength over all spaces which occur between groups of artificial teeth, otherwise it will crack at these points and the adjoining teeth will be displaced. In cases, too, where the teeth are fitted to the plate, which extends more or less beyond their necks, care must be taken that the investient is left of full thickness along its border for the same reason.

The next step, when the plaster has set, is to clear the wax cement from the backs of the teeth and joints; after getting the cement away in block (which is done by applying the small gas jet to the edge of the plate), boiling water may be used so as more thoroughly to cleanse the joints.

All parts to be soldered are then scraped, borax applied, and any joint not perfectly close must be packed with a small cutting of gold. The solder is arranged along the joints and over each pin, and the case is then dried, slowly at first, lest the borax should swell and displace the solder. The drying may be completed over the bunsen, and the case at once heated up by the blowpipe and soldered; but the usual and perhaps best plan is, after it is dried, to place the case in the fire (or stove) and heat it up to a low red before soldering. When the heat of the plate is brought up by the blowpipe a strong blue-white flame is used first over the investing material. When plate and plaster are brought to a red heat the pointed white flame is made to beat in the neighbourhood of, rather than on, the solder; when the latter begins to give way the flame is sharply turned upon the solder, and thus the operation should be satisfactorily accomplished.

There are cases, however, where special difficulties are met with; such, for example, as have detached teeth to be soldered, the joints of which lie in a deep recess, with high clasps on each side. Here the difficulty is to solder the joint without melting the clasp. Sometimes a morsel of plaster or pumice-stone placed against the clasp will effectually protect it, and direct the flame to the point to be soldered. But the best plan is to use a slightly inferior quality of solder for the most difficult joints —Ash's No. 3, for example, the clasps having been soldered with No. 2.

In these cases, also, the investing material and the main plate should be heated very highly—keeping the flame from the clasps—before turning a very pointed flame upon the joint.

The case having been soldered is allowed to cool gradually before taking it from the investient. It is said that this gradual and thorough cooling is necessary in order that the teeth may be properly tempered, as with glass, taking them from the investient while hot, leaving them brittle. The plate is then placed in the cleaning acid, or "pickle," which if heated will act much quicker in cleaning the surface of the gold and dissolving the vitrified borax adhering to it.

Warping of Plates.—When placed upon the model, the plate which has just been soldered is found to have more or less altered in fit. It grasps (if it be a large upper) along its outer edges on both sides of the model, and it is open along the line of the palate. The gold, in common with other metals, expands when heated; but when that natural ex-

pansion is not interfered with—as, for instance, in the earlier stages of construction—no change of fit occurred in consequence. But when the plate is enveloped in plaster, free and therefore harmless expansion is impossible; the metal still expands, but it does so in an irregular manner—becomes distorted, or warped. The shrinkage of the solder after setting is spoken of as possibly helping the warp by drawing the plate; the other, however, may be taken as the main cause. In our own experience we have found that the best results are obtained by limiting the quantity of investing material about the plate to the smallest dimensions, consistent with a proper holding of the teeth and plate together; by this means the warping may not be got rid of in all cases, but the evil appears seldomer and is of less extent when this plan is employed than by any other with which we are acquainted. It has not been explained how the copper frames,* or saucers, recommended as a means of preventing warping, *act* for this purpose; but the idea seems to be that they will in some way still further bind the plate and prevent its expansion.

If the theory stated above be correct, it would appear that the plate is bound too much already, and that any further binding can only increase the evil. It is doubtful, however, whether these frames have any direct influence upon the plate one way or the other; and the objection to their use arises

* These are strips of copper plate bent into oblong or semi-circles of various sizes; they are filled with the investing material, and the denture is then imbedded.

more from the fact that by employing them a quantity of investing material is made to surround the plate, quite unnecessary for the purpose of holding the teeth, and which adds considerably to the chances of warping.

Finishing.—The finishing of a plate is frequently made unnecessarily difficult by a careless use of the file during its construction. The latter should be used with precision, so that only those points which *must* be reduced are touched by it; a few careless slips of the file leave marks which can only be effaced by expending much time and labour which would otherwise have been unnecessary. Again, the blowpipe should be used so as to leave the joints of clasps and teeth with a perfectly smooth and well-shaped surface, requiring neither file nor graver to be used upon them.

Many dentists disapprove of giving a high polish to plates, and consider it sufficient if they are well made and smooth. In such circumstances the method adopted is to stone the filed edges and go over the general surface with the polishing stick and damp pumice, after which they would be considered finished sufficiently well for inserting in the mouth.

Where a high polish or "shine" is required to be given in a short time, the "skin," always found upon gold at this stage, must be taken off by means of the scratch-brush, or by using a carefully sharpened graver, to lightly scrape the surface, as is done in finishing vulcanite cases. Water of Ayr stone, cut to different shaped points, must then be used over the surface, moistening the

cutting points frequently with water; a quick light motion of the stone is most effective. Sometimes pumice-stone, cut into pencils, is used instead of the Scotch stone, but the latter is generally preferred. When the file and graver marks have been effaced by these means, the plate is taken to the polishing lathe so that the marks of the stone in turn may be effaced. For this purpose the circular hair-brush is charged with ground pumice moistened with water, oil, or molasses; the two last keep the abrading material to its work more effectually than the water. While it is being polished at the wheel the plate should be kept in constant motion, and where there are clasps these should be protected by the fingers closing over them, otherwise they are liable to be cut and disfigured by the wheel. After the pumice has done its work the plate must be thoroughly washed; the polishing is then completed on the rouge-wheel, which is at first used damp, the polishing material, well mixed with water, being added to the plate and brush; the latter is at last used dry, and revolving at a higher speed.

For those parts of the plate which the wheel cannot reach, pieces of soft wood charged with the polishing materials may be used. Some dentists do not use the scratch-brush or graver to take the "skin" off the gold; but in that case one must either be content with an inferior polish or much additional time must be given to the stoning process.

Tube Teeth attached to Gold Plates.—In those cases where the teeth are required to fit the

gum, or as in upper sets where some are to fit the gum and some the plate, the same method should, to a certain extent, be adopted as that which has been described in connection with flat teeth. There are two points, however, which should be remembered. The tube teeth when fitted, in the first instance without the plate, to the model and bite, should be left sufficiently long to allow for fine fitting when the pins are soldered. And again, the gum border of the plate must be reduced with relation to the position which the "pins" must occupy, as well as to the traced line on the model. For instance, the tubes of many incisors (Ash's always) are quite close to the front border of the tooth where it fits the gum, so that unless the plate is left as "full" as the traced line itself, the pin could not be inserted in its true position. In such cases, after having rough fitted the incisors to the model alone, it is generally advisable to cement them to the plate and take the position of the pins, leaving the operation of cutting the gum border of the plate until the pins are soldered, when it can be done readily and without risk.

The plate having been replaced on the model, the teeth—the tubes of which must be cleansed of the débris of platinum and mineral left by the corundum wheel—are cemented to it in accurate position, and the places for the pins ascertained by passing a wire, tipped with rose-pink or vermilion, down each tube; this leaves colour marks on the plate which indicate exactly where the holes must be made for the insertion of the pins. The wire used for *marking* should be carefully made and

preserved for this special purpose. It may be made of iron or steel wire, and should fit the tube easily, but not loosely, and the marking end should be filed or ground to a centre *point*. A flat-ended wire is sometimes used, but a moment's consideration shows that it must almost invariably be misleading. For when it is passed down the tube the plate with which it comes in contact being, not a plane, but a more or less irregular surface, part only of the marker touches the plate, and that not the central part. But it is taken as the centre, and consequently the teeth will be set out of position.

The teeth having been carefully removed from the plate, the next step is drilling the holes. First a slight countersink is made at the centre of each colour-mark by a suitable edge tool; this gives a catch to the drill, which is then made to pierce each hole in succession.* This will be best accomplished by keeping the plate on the model, and the drill must act in the line required for the position of the tooth. The one used is generally smaller than pin size, so that the broach, while widening the hole to the required size, may at the same time correct any error in direction or angle which may have been given by the drill. The rough edge left on the plate by the drill and broach must then be taken away, and the pins—the ends of which have been cleaned by the touch of a file or graver—are

* Perforating pliers should never be used for this work. They *bend the plate*, and the position for the pins cannot be obtained with the same accuracy as with the drill. The superiority of the latter indeed requires no demonstration, and the old objectionable practice of using perforators for this work is now rarely heard of.

inserted by the aid of pliers. They must not be wedged too tight, or the solder will not run through, but just tight enough to retain the position they are placed in, during the soldering process. The joints are then treated with borax solution and soldered. The solder is generally applied on the upper or lingual side of the plate, but in some cases (between clasps for example, or in deep hollows) it is more convenient to solder from the inside of the plate. Very small pieces of solder must be used for this work; the broad blue-white flame is used to heat up with, and if the plate be well heated in this manner the solder will flow

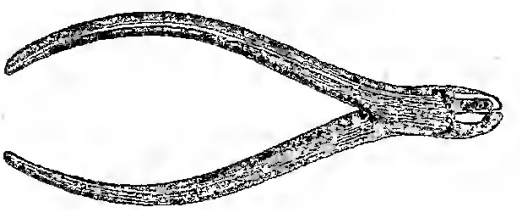


Fig. 52. Cutting Pliers.

perfectly; the charcoal support should be moved in such a manner that the flame shall act on all parts of the surface, and also partly underneath the plate, so as to *draw* the solder through. After soldering, the ends of the pins on the inside must be reduced to the level of the plate; this is done with small beaked cutting pliers (Fig. 52) and gravers; and sometimes the pins are then flushed on the inside surface by a second soldering, but this is unnecessary if the solder has been drawn through —as it ought to be in all cases—from the one side of the plate to the other.

Another method of drilling the holes for the pins

may be mentioned, which does away with the necessity of marking, and by which the drill must take the direction required by the tooth. The teeth, having been cemented to the plate, are then surrounded with plaster in sufficient quantity, and formed round teeth and plate in such a manner, as to retain them fixed in position while the drill itself passes along each tube, and at once pierces the plate. The drill used for this work must be carefully pointed, and must be easy in the tube without being loose.

The method first explained will, if properly worked, give perfectly accurate results, and is to be preferred to the other, in our opinion, as having fewer risks. Where there are a number of teeth, it will be found a good plan to solder one or, perhaps, two pins, and get them accurately in position; these then furnish a guide for inserting all the others in the one operation. We next proceed, after they have been soldered and ascertained to be perfectly placed, to fit the pins accurately to the bite. The plate is placed upon the model, and the pins are cut and filed as the bite touches until the latter is quite home and the articulation exact.

This plan not only allows us to get *at once* done with the pin-cutting, but it affords us a certain guide for the fitting of the teeth, to which our attention is now wholly directed.

The incisors (supposing the case to be a complete upper) must of course be fitted not only according to bite and gum, but their length, or the extent to which they should close *over* the lower incisors must depend also upon whether the patient

shows the teeth much or little. The bicuspids and molars,* on the other hand, depend altogether upon the bite and plate; and as we know that the pins are cut exactly to the required articulation, we may go on with the fitting of these teeth without consulting bite or model until the pins appear at the tops of the tubes. It is often best, however, to contrive that the teeth shall closely fit the plate—fine fit as it is called—before the pin quite reaches the top of the tube. Then the teeth of the *bite* are coloured with pigment, and the artificial crowns ground to a perfect articulation with them.

Swivels.—As a means of retaining sets of teeth in position, swivels and spiral springs are now seldom employed; nevertheless, it will be well here to explain the method by which they are usually attached. They are generally fixed to the plate after the pins have been soldered and the teeth fitted. The positions which the swivels must occupy depend altogether upon the positions of the teeth; they must be soldered to the plate so that the spiral springs, which are afterwards attached to them, shall act in a line parallel with the faces of the molars and bicuspids, and as a rule close to these surfaces. Otherwise the position chosen for the swivels should be that which will best balance the set. Between the bicuspids is, perhaps, the average place given to the upper ones, and the lower are placed exactly below the upper, or *very*

* These teeth are usually only fitted in the first instance sufficiently to sit steady on the plate while the positions for the pins are being marked; the bulk of the fitting therefore takes place after the pins are soldered.

slightly forward. Four pieces of plate must be cut —about one-eighth square, or a little over—a hole is punched through the centre of each, and made of such a size that the swivel-bolt will go tightly through it. These are the "checks," or standards, which must be soldered to the plate, and against which the swivels are to work. The standard is placed in that position on the plate, and against the teeth, which the swivel must occupy, and its lower edge is filed if necessary to fit the irregularities of the plate; marks are then made upon the latter with a sharp point, so as to take the exact position of the standard, so that when the teeth are removed it may be replaced accurately upon the plate and soldered. The teeth are then taken off, and a cut made with file or graver point along the line where the standard is to be fixed; this gives a catch which prevents the latter from slipping while tying it for soldering. A thread of binding wire is then passed through the hole in the standard, which is then placed in position and bound down tightly with the wire. This should leave it lying flat upon the main plate; and now by raising it gently to its proper position the strand of wire will tighten and fix it sufficiently for soldering (Fig. 53). For this of course the joints should have been prepared in the usual way, and the flame and other directions given for soldering the pins will be suitable for this work.

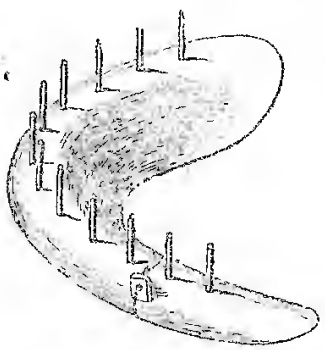


Fig. 53. Upper Plate with "standard" tied, ready for soldering.

It is a good plan to "tack" the standard first with one small piece of solder; then the teeth should be tried on to test its accuracy of position, which can be easily corrected if found slightly false in angle. The soldering is then completed, using a thread of wire as before; and a very small piece of pumice-stone or coke will be found most useful if placed at the back of the standard, for binding against and preventing it from falling back upon the plate during the soldering. Now the swivel and bolt are to be passed through the hole, and the bolt soldered at the joint at the back of the standard; but if that was done without further preparation, the solder would most likely pass through from one side of the joint to the other, and "fix" the swivel. To prevent this it is not sufficient to work in whiting from the circumference of the swivel after it has been inserted in the standard. *Before* inserting it, whiting made into a thin paste with water must be carefully coated over the surface of the swivel and joint which is to come into contact with the standard; these parts may then be inserted, and the joint at the back of the standard should be scraped and touched very slightly with the solution of borax. Fig. 54 represents a swivel with bolt of full length; also one with bolt cut, for insertion into standard; the third cut represents the swivel without bolt. The solder having been placed, the plate should be well heated up, and a pointed blue-white flame used to reduce the solder. Such is the method which will be found

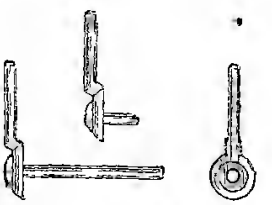


Fig. 54. Swivels with Bolts.

most suitable for the majority of cases; there are others, however, where different treatment is necessary, as, for instance, where the hole for the swivel-bolt must be pierced through the main plate; but the points already noticed indicate generally the essential considerations.

Fastening Tube-teeth to the Plate.—The plate having been "pickled" and "stoned," is then ready to have the tube-teeth fixed upon it. To accomplish this properly the tubes must be made thoroughly clean, and the pins on the plate should be scraped and "barbed," or roughened slightly with a graver edge. The teeth are then put on, and the plate, being held in the pliers, is heated carefully over the bunsen flame; sulphur (in powder) is then placed at the top of each pin, and if the plate has been properly heated the sulphur will melt and flow down the tube and pin; the case is then allowed to cool, and the teeth will be found thoroughly secured. Another method, and one it is well to adopt in certain cases, is to heat the plate over the bunsen flame *before* putting on the teeth, and give each pin a coating of sulphur; the teeth are then heated one after the other over the flame to such a degree, that when placed upon the pins their own heat will melt the sulphur, as they are passed over the pins. This requires a little more time than the other method, but it is very certain in its results.

CHAPTER VIII.

VULCANITE WORK.

Complete Sets.—Shallow plaster models having been cast from the impressions taken of the mouth, it is then necessary to obtain the "bite."

In order to obtain perfectly accurate results, a rigid base plate is required on which to mount the biting-blocks. In the work just left the gold plates themselves answered admirably for this purpose; but in the construction of vulcanite sets the only plate available is one of wax or gutta-percha, and neither of these by itself is able to resist the force exerted upon it by the patient in biting. Some strike Britannia-metal plates—thickness of modelling wax—for the models, and upon these set the biting-blocks, and afterwards the teeth. The time required for preparing these plates is the great objection to their use; otherwise they answer the purpose well.

Perfectly satisfactory results can, however, be obtained in a few minutes by the following method. Damp the surface of the plaster model well, and make a gutta-percha plate upon it, extending over the palate. Then take an iron wire (pin size) of

suitable length, and bend it to fit across the floor of the palate, with its ends extending up and over the alveolar ridge, at the point to be occupied by the first or second molar. The wire is next heated over the bunsen and sunk in position upon the gutta-percha, which being softened along the whole line by the heat thus imparted to it, can be at once closed over the wire with the finger. The plates prepared in this manner will be found perfectly rigid in the line along which the force in biting is exerted. The wax biting-blocks are mounted upon the gutta-percha plates, and the bite is taken, and cast in plaster in the manner already described in connection with gold work.

When the plaster bite has been "taken off," the gutta-percha plates are then removed from the models, which must now have wax plates made for them, and upon these the teeth are set. In softening the modelling wax for this purpose care should be taken not to melt its surface, and in closing it to the model very slight pressure should be employed; otherwise the uniform thickness which we desire to reproduce in vulcanite will be destroyed. When adding wax for supporting the teeth to a higher level than the plate itself would give, or afterwards when modelling up the piece to the desired outline, it is much better to use softened strips of wax, where the additions are required, than to drop melted wax upon the plate until the height and shape is obtained. By the latter method not only is time lost, but too often a clumsy ill-made piece is the result. By the former we can at once attach to the plate a skeleton frame of soft

wax, in which the teeth may one after the other be placed to the required height and fulness, dropping wax behind each as its true position is obtained. This will also be found to be the best means of obtaining a *shapely* piece.

Before setting the teeth their pins must be bent in such a manner as will best keep them firmly fixed in the vulcanite; and the pliers used should have such surfaces as will *roughen* the pins while bending them: For the more effectual holding of the pins, instead of bending them, cross wires of platina are sometimes soldered to their extremities; but this practice need only be adopted in very exceptional cases. The pins, of the length and strength which is usual among the teeth of the present day, are well fixed in the vulcanite by bending as described, and having the surfaces clean while packing. In the case of a complete upper and lower, the lower teeth are first mounted accurately in position, using the wax-block on the upper model as guide. This block has been cut when taking the bite to the exact fulness required for the case, and if the lower teeth are set so that their points will come slightly within the face of the upper block they must be correct. When they are fastened in position, and the wax is modelled up to the required form, the upper teeth are then set to the lowers. The centre line must be carefully worked to, and the points of the upper incisors must be made to close over the lowers, while the bicuspids and molars should be made to fit well to each other, grinding their crowns if necessary. It is most important that there should be a good

articulation; where the bicuspids can be got to "lock," or close *between* the opposite crowns, this may readily be obtained; but where the cusps close perpendicularly upon each other, considerable grinding of the surfaces will be required. "Locking" may often be obtained by a slight spacing of the incisors which may allow the cusps of one set to close between the cusps of the other.

Swivels.—If swivels are required for a vulcanite set, they may be inserted either after the case is vulcanized and finished, by drilling through the vulcanite, or they may be inserted at this stage, viz. when the teeth have been arranged and the wax modelled into the required form. If the latter plan be adopted, the "bolt" of the swivel need not be left over a quarter of an inch long, and it should be *barbed* with a graver;* and when it is inserted into the wax it should not be heated but pressed in cold, otherwise some trouble may be experienced from the loosening of the swivel in the wax. By adopting this method, springs may be attached to the swivels for trying the case in the mouth if care be exercised. This plan of trying in a set with springs attached is regularly practised by some dentists, whether the case be ultimately intended to have springs or to be without. A special set of swivels is made and reserved for this purpose; their "bolts" are fixed into square

* The bolts are sometimes crushed between the jaws of the "vise," but this is a plan which cannot be recommended. A slightly barbed bolt holds perfectly in the vulcanite, and should it be necessary afterwards to extract it from the latter, that can be readily accomplished; not so if the other method of roughening be adopted.

pieces of wood or gutta-percha, which gives them a good hold in the wax. They may be inserted in the *biting-block* after it is pared to shape, and thus an additional help be secured towards obtaining a correct bite.

Firing Models.—Upon these the cases are "flasked," packed, and vulcanized. The first or original model may be used for this purpose, or a second one taken from the original may be employed. The usual, and perhaps the best, practice is to use the original for firing upon for all edentulous cases; but for most partial cases the other method is adopted, the original model being retained for use after the piece has been vulcanized. The firing models must in all cases be made shallow; and where the artificial teeth are *long*, the case and model should be tried in the flask before mixing the plaster, to make certain that the points of the teeth are ranged well below the border of the upper half of the flask. The cases are cemented to the firing models by a hot knife used round the plaster and wax border.

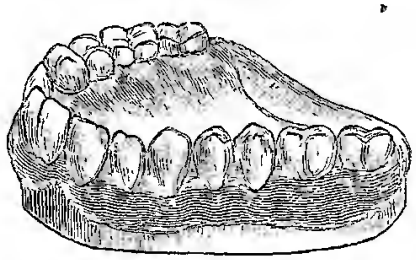
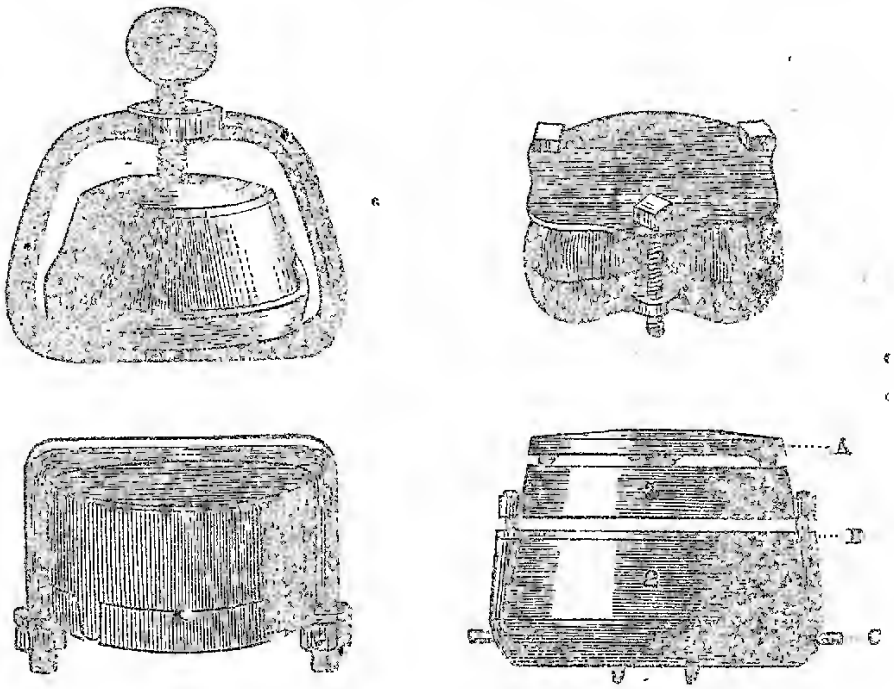


Fig. 55. Set of Teeth on Firing Model.

Should a "chamber" be required for a suction upper, the "shape"—which may be made of lead, &c., the thickness of modelling wax—is cemented to the upper (lingual) surface of the wax plate; but after separating the flask, and before packing, it must be fastened in position on the palate of the model.

Flasks.—These may be had in a great variety of patterns, but they may be generally described as consisting of two kinds—first, those which are made in two main parts or chambers; and second, those made in three main parts; in both, a lid, which may be considered the third and fourth parts respectively, completes the flask. Fig. 56 shows a flask of the



Figs. 56, 57, 58, and 59. Vulcanizing Flasks.

first description, the parts being fastened together by a clamp. Fig. 57 shows a flask of the same kind made by Whitney, in which the parts are secured by three screws. Another method of fastening is to use a simple stirrup or narrow metal band, which is tightened upon the flask by inserting an iron wedge. In Fig. 58 we have one of a very useful description largely employed by dentists.

Fig. 59 represents one made according to the second principle, having three parts and lid; this flask was introduced by Messrs. Bell and Turner.

The first kind (those having two parts) are used where the model and teeth are to be held in different chambers of the flask, the vulcanite being packed in the upper chamber (containing the teeth), which is then closed upon the lower which contains the model. The second kind are used

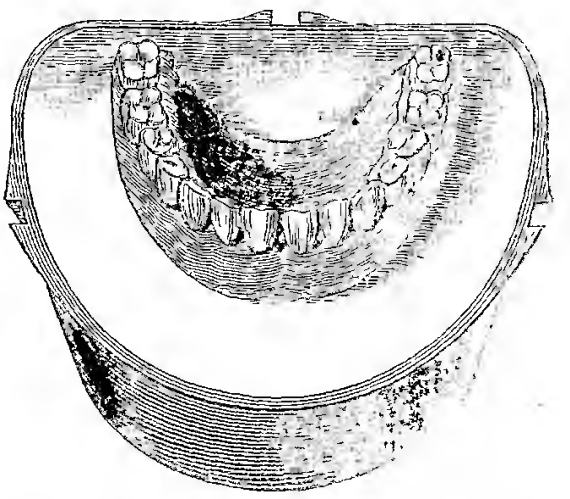


Fig. 60. Upper Set imbedded in lower part of Flask.

where teeth and model are to be held together in the *same* chamber, the vulcanite being packed in such cases directly upon the model. Both flasks are required in the work-room, for though it is certain that the best results are obtained in nearly all cases by using the latter description, the others may occasionally be used with advantage for new work, and they are the most convenient for repairs.

The two-part flask is worked in the following manner. The bottom chamber is two-thirds

filled with thickly mixed plaster, and the firing model is at once sunk in it, the plaster being brought up to the edge of the wax, from which it slopes down to the border of the flask, which must be left clear, so that the upper part will close perfectly upon the metal of the lower. The plaster surface must be made smooth and well oiled or soaped, the teeth being left untouched. The filling of the second chamber requires great care, so as to avoid the "blows," or air cavities, which may form about the teeth, and may be the cause of their changing position. Sufficient plaster having been mixed to fill the flask, some of it is taken up on a tooth-brush and rubbed thoroughly over all parts of the teeth and gums, when a thicker coating may then be quickly applied; the second part of the flask is next put on, and the chamber is completely filled with plaster, and the lid pressed down into position. This manner of filling a flask will effectually prevent the faults referred to, but some quickness of action is necessary, so as to finish the work before the plaster becomes too thick. When the latter is set, the flask should be slightly warmed, and the parts separated by prising at opposite parts of the joint. Before removing the wax, its form and outlines should be noted, as the recollection will assist the manipulator when afterwards disposing the vulcanite in packing. Boiling water is used to remove the wax which may not be readily taken away with a knife. Grooves may now be cut in the plaster with a graver, from the borders of the flask up to the model. These "gates" are provided so that any excess of vulcanite shall readily

escape, and not interfere with the closing of the flask after the packing has been completed. It will be found, however, much more satisfactory to take some trouble to ensure that only the proper quantity of vulcanite be packed into the mould. With the most complete supply of "gates," if there is much excess of rubber the case will be a failure, and with careful packing the "gates" are scarcely required. The flask must be heated before commencing to pack; this may be done by steam or by dry heat. If the former is employed, the flask should not be allowed to lie surrounded by the water, but should be raised, so that only the steam will act upon it. But whichever plan be adopted, the heating should be carefully attended to, and whenever the flask reaches the point beyond that which can be well borne by the hand, the packing should be proceeded with. *Overheating*, either by steam or dry heat, *completely destroys the plaster*, so that when the least pressure is employed it gives way, and the success of the case is endangered.

Preparing the Vulcanite.—First, as has been already stated, it is most important to pack the case with *just* the quantity of vulcanite required. This quantity may be found by weighing the wax —which must be taken from the mould in a very complete manner; then by knowing the respective specific gravities of wax and the vulcanite used, we are enabled to find the quantity of vulcanite required to fill up the space before occupied by the wax. For example, the specific gravity of wax is 0·96; and Professor Austen states the specific

gravity of American red rubber as 1·572. Hence to fill the mould when pure wax is used for a

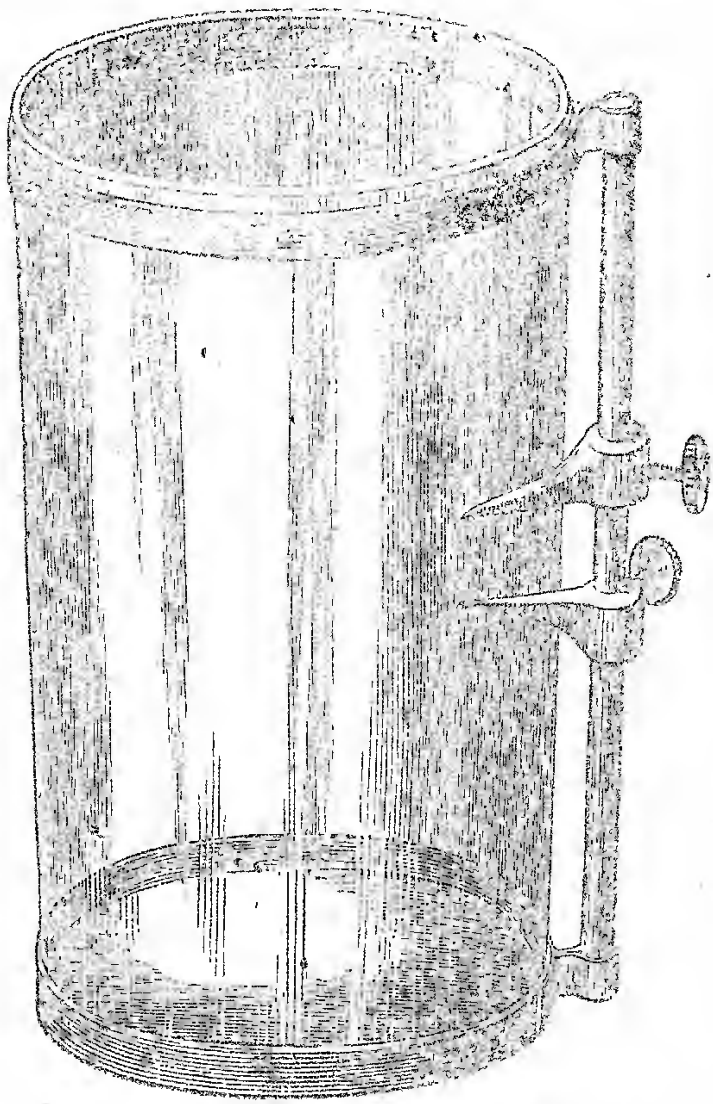


Fig. 61. Glass for ascertaining the amount of Vulcanite required for any case.

model plate, it will require to 1 part of wax by weight 1·6 of the red rubber.

This plan is not, for obvious reasons, a very

convenient one to adopt. A readier method is to obtain at once bulk of vulcanite for bulk of wax. This is done in the following manner. A suitable glass vessel (Fig. 61) is filled to a certain point with water; the wax is then immersed, when the water of course rises to a higher level; this higher point must be marked; the wax is then taken out, and vulcanite is put into the tumbler until the water again reaches the higher level. It will be found much more satisfactory to take this measurement *before* the case is secured to the firing model. Then it represents exactly the bulk desired plus

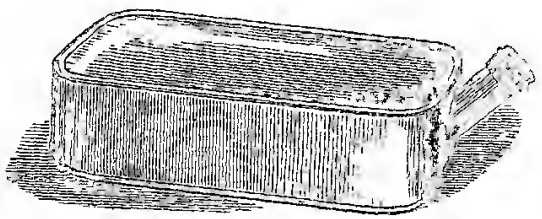


Fig. 62. Heater for Vulcanite.

the bulk of the artificial teeth; and this surplus is required so as to allow for the consolidation of the vulcanite in the "press." For the above purpose a graduated glass is most convenient, but a common tumbler and colour marks may be used.

The vulcanite is then cut into pieces most suitable in size for the case in hand. Narrow strips must be provided for packing round the pins of the teeth, and the pieces increase in size as the work proceeds, large squares being used for the broad palate of an upper. The most convenient heater for the vulcanite is a tinned iron or zinc box about an inch deep, containing water, and fixed so that

the flame of a bunsen may be applied below to maintain the heat.

Packing.—The upper part of the flask, or counter, as it may be called, in which the packing is done, should be well wrapped round with a towel before commencing operations; this will in great measure preserve the heat. The narrow strips of the "base" rubber are first packed below and round the platina pins; then the smaller pieces of gum are packed between the teeth, and the larger used to complete the "facing." The surface left upon the gum rubber should be continuous or solid; if joints are left over the surface, such as those made by pieces imperfectly packed together, the red rubber will come between, and probably appear through the facing of gum when the case is finished. The packing of the "base rubber" is now proceeded with in the deep parts of the mould at the back of the teeth, and from this point the work may be done more rapidly; over the palate of a suction upper the large squares of vulcanite are simply placed in position, the pressure afterwards employed being sufficient to consolidate the parts.

Packing will be found a simple enough process if it is commenced with a sufficiently hot mould, and if the operation is finished before the latter becomes cold.

To ascertain the condition of the work after closing, a piece of damped cloth* of sufficient size is placed over the vulcanite after packing; the parts are then put together and the flask placed in

* That found between the sheets of vulcanite is very suitable.

the press or vice, where it is closed by a gradual and equal application of the force. It is then separated carefully and the cloth removed; any difficulty in regard to the latter may be readily overcome by thoroughly damping the adhering parts. Should there be a deficiency of vulcanite, additions must be made to the defective parts; should there be an *excess*, that is removed by using a hot knife. When the faults have been corrected the flask is perfectly closed in the press; it is then fastened by its clamp and vulcanized.

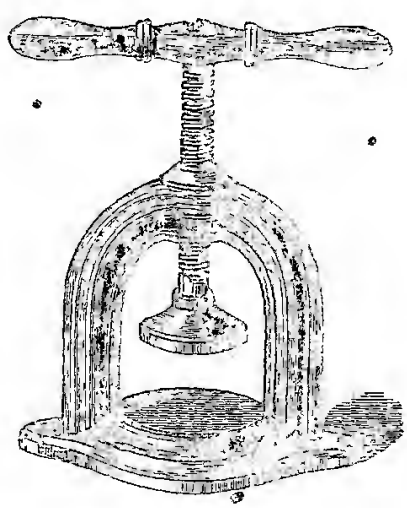


Fig. 63. Press for closing Flasks after packing.

The second kind of flask —that having three parts —is generally used for those cases in which the model and teeth are enclosed in the one chamber and held together by the one plaster. The first and second parts of such a flask when put together should form a chamber large enough to receive any firing model with the denture attached, and the superior border of the metal should be higher than the points of the artificial teeth. This chamber having been more or less filled with plaster,* the firing model and denture (the teeth of the latter having been brushed and coated with plaster) are

* The quantity of course depends upon the dimensions of the case to be imbedded, but it is better to mix an excess of plaster rather than a deficiency.

imbedded in it, so that the points of the artificial teeth shall lie slightly below the metal border; as the case is pressed down into this position the plaster rises up over the teeth, the crowns of which should also be covered with it. Thus the only part of the case left exposed is the lingual surface of the wax plate. The plaster must have a surface favourable for parting; and when it is set and thoroughly oiled or soaped, the third part of the flask is put on and filled with plaster, and the lid pressed into position. The "two-part flask" might be used for working upon this plan, but its lower chamber is so shallow that the teeth stand high above its border, and the plaster, which must therefore be brought up over their faces and points, is unsupported by metal, and very subject to break in a serious manner both in packing and closing the flask. If this flask be employed, however, its order of parts should be reversed; make the lid and upper part together the bottom chamber, into which, it being filled with plaster, the case is imbedded; the bottom part may then be used as the new upper chamber and lid in one.

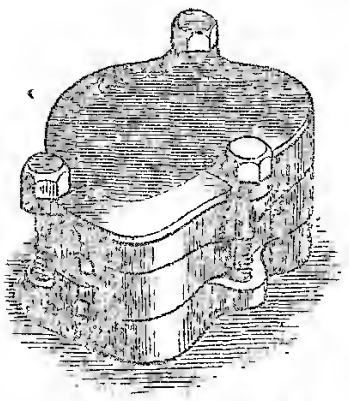


Fig. 64. Three-part Flask.

For many years we have used one somewhat similar to the "Bell and Turner" three-part flask, and find it most convenient for this kind of work. The accompanying figures explain themselves. In Fig. 65 we see the chamber (1, 2), with the protect-

ing flange round the superior border of the arch—in which the case is imbedded. It is rather smaller in size, and wants the details of fixing pins and diaphragm and "bottom ribs" of that flask, and

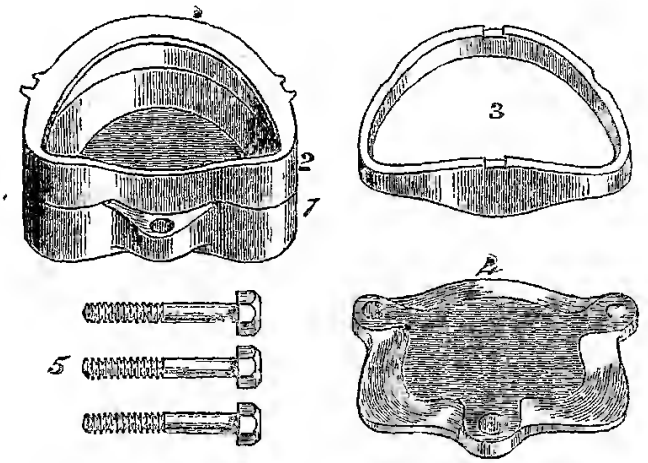


Fig. 65. Three-part Flask.

the arch of the superior border of the second part is formed into a narrow flange, which gives additional strength to the plaster covering the teeth, the points of which when the case is imbedded are ranged under it. Fig. 66 gives a view in section of this flask with a case of teeth in position.

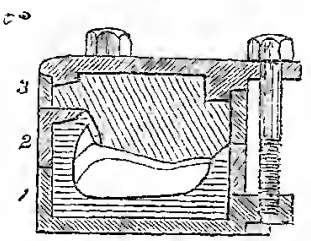


Fig. 66. Three-part Flask in section.

The "Contour flask" we have used, but found the arrangement for packing and pressing from behind a very inconvenient one; it is, however, very highly spoken of by several dentists.

The details already given in connection with the packing process sufficiently indicate the essential points to be observed in all cases. In the present

instance the packing is of course done in that part of the flask containing the model and teeth, commencing with the pink or facing rubber which is carefully packed between the teeth and otherwise as the case requires; the packing of the base rubber is then proceeded with and continued as far over the model and palate as the finished case is designed to reach; the damp cloth is then placed over the vulcanite, and the closing of the flask proceeded with in the manner already explained.

This last method of working is in every respect superior to the other. In the great majority of cases a *perfect* closure of a flask is not obtained, and therefore a thickening, or "rising," over the whole surface involved in the closing of the parts is the result. With the two-part flask, as the teeth and vulcanite are closed together upon the model, the teeth are of course involved to the same extent as the rest of the case in any thickening which occurs. This change is most noticeable in partial pieces, or in others in which the teeth were closely fitted to the gum; in these the new thickness of vulcanite below the teeth is plainly seen, and the latter stand much higher than they ought to do both for bite and appearance. In such cases, where the piece is "raised," as it is called, the fault can only be corrected by the unsatisfactory and tedious plan of fitting it down on the plaster model, or by grinding from the points of the teeth themselves.

But by adopting the second method of flasking, the teeth are fixed to the model throughout the whole process of packing and closing; their relation to it, therefore, remains constant and unchanged,

and any thickening which may occur can only affect the vulcanite *behind* the teeth and extending over the palate; this is a change of little consequence, and the thickness can readily be reduced by using the file or graver on the lingual surface of the vulcanite plate. We should, therefore, adopt this plan as a rule on all occasions. There are some exceptional cases where the two-part flask is the better one to use—these are mostly lower sets—but those who have become accustomed to pack on the model will make an effort to do so even in these more unfavourable cases. There are certain sets, for example, where the artificial teeth are set almost if not quite on the plaster gum, and in front of these and over the face of the alveolar ridge it is necessary to pack a considerable amount of vulcanite. In such cases it is best, when casting the lower section of flask, to bring the plaster up to the tips of the teeth only—leaving the crowns free. That permits of the teeth being readily removed when the flask is opened and cleared of wax. The packing of the gum is then easily accomplished, the teeth replaced, and the packing proceeded with in the usual manner.

The three-part flask can be used in another way to overcome peculiar difficulties. Plaster is filled into its first or bottom part only, and the model imbedded as described in connection with the *first* process, the plaster being brought up more or less over the facing wax, but leaving the teeth free: its surface is then smoothed and oiled, and the second part of the flask being put on, plaster is filled round and over the teeth, as described for the *second* pro-

cess, leaving the lingual surface of the wax plate clear. This plaster surface is in its turn oiled, and the third part having been put on, the flask is filled with plaster and the lid pressed down. Thus it can be separated at both joints, and the case packed at all parts. This mode of working, however, is not without difficulties of its own, on which account it is avoided as much as possible.

Partial Cases in Vulcanite.—If the artificial teeth are required to fit the gum, the same practice may be adopted as with plates; having fitted and arranged the teeth on the model, the modelling wax is then softened and pressed to the latter, bringing it up to join that which fastens the teeth, and fusing the joint with a hot knife. If it is necessary to remove the case from the model, the removal should not be attempted until the wax is quite set.

Clasps.—These may be made from "band gold," and fitted to the teeth in the same manner as that described in connection with plate work. The same care must also be taken to allow them to have ample freedom of action along the holding surfaces of the natural teeth; let them also be as high round the walls of the latter as possible. Broad, thin, and freely acting clasps are the most satisfactory of all. The catches soldered to hold them in the vulcanite must be attached so as not to prevent the required elasticity, and at the same time so placed that they shall be well imbedded in a sufficiently strong part of the vulcanite. For example, the double bicuspid clasp, acting on both sides of the tooth, should have its catch soldered only over a small part of the back of the clasp for the first reason, and as

near the gum border as possible for the second. They should be made of stouter plate than that from which the clasp is made, and should be soldered *strongly* to the latter. The most convenient and generally useful catch is a small piece of plate somewhat triangular in form, soldered so that its base shall lie near the gum and its apex towards the superior border of the clasp. This gives a most effective hold, and from the shape there is little risk of its becoming exposed while "finishing" the piece.

Clasps may also be made of vulcanite, in which case it is of course necessary to mould wax round the teeth, so as to represent in all respects the clasp required. The holding surfaces of the teeth to be covered should be *slightly* pared in the firing model, so that when the case is finished the clasps shall *grasp* the natural teeth. This kind of clasp is seldom used except for large crowned molars. When these teeth stand isolated, the vulcanite can be made to encircle them in the shape of a broad ring, and this is frequently the most effective manner in which a case can be supported in the mouth. The ring should be as broad as the shape of the tooth will allow. In other cases, where the ring cannot be used, the vulcanite clasp should be made to come well round the face of the tooth; it should be made also of the strongest rubber; and a considerable space must be provided between the artificial tooth and the plaster one where a vulcanite clasp is required to come between, otherwise the latter will be in great danger of breaking at that point. When a case of this kind is flasked, if the artificial teeth are covered over as in the second

method of flasking, the plaster must be cleared from the crowns of those plaster teeth which are clasped, so as to expose the superior border of the wax which covers their faces. This is necessary in order that the rubber may be properly *packed* at those parts. Of course this is done before the upper part of the flask is filled.

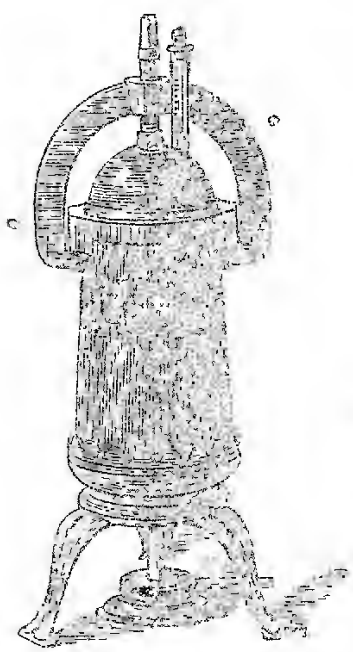
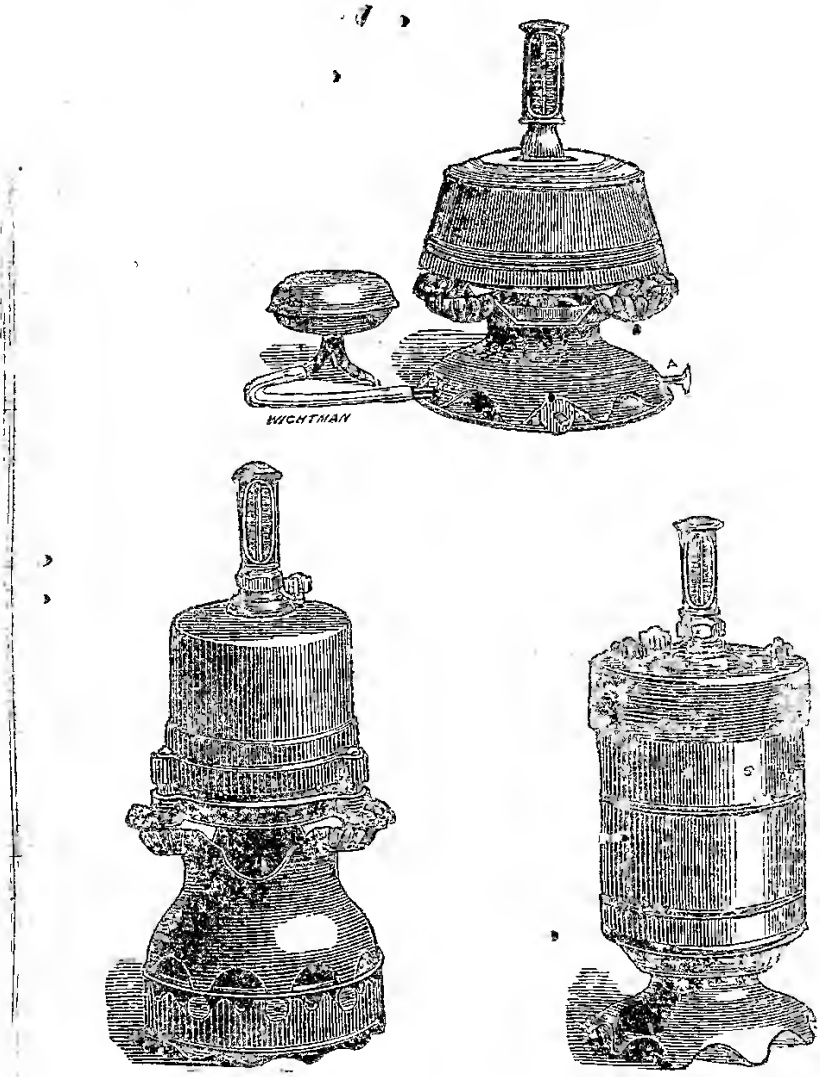


Fig. 67. Vulcanizer.

Vulcanizers and Vulcanizing.—"It is scarcely to be believed," says Professor Austen, "as we look upon the small copper chambers standing upon the bench in which vulcanizing at present takes place, that the first vulcanizer introduced by Mr. Putnam weighed 1,200 pounds, and required the constant care of an engineer. This was discarded for one of 350 pounds, which in its turn made way for one of 100 pounds, and this was considered the highest improvement of cast-iron vulcanizers."

Those of the present day stand upon the bench, and are only some 12 or 15 inches high over all, and 5 inches diameter; the chamber itself is generally made of copper. The one of most convenient construction, according to our experience, is secured or closed by means of one large centre screw which acts upon a dome-shaped lid (Fig. 67). There is no *valve*, but a fusible metal plug inserted in the lid provides

against all danger of the bursting of the vulcanizer, by melting at from 345° to 350° F.; by standing beside the vulcanizer for three minutes when the heat

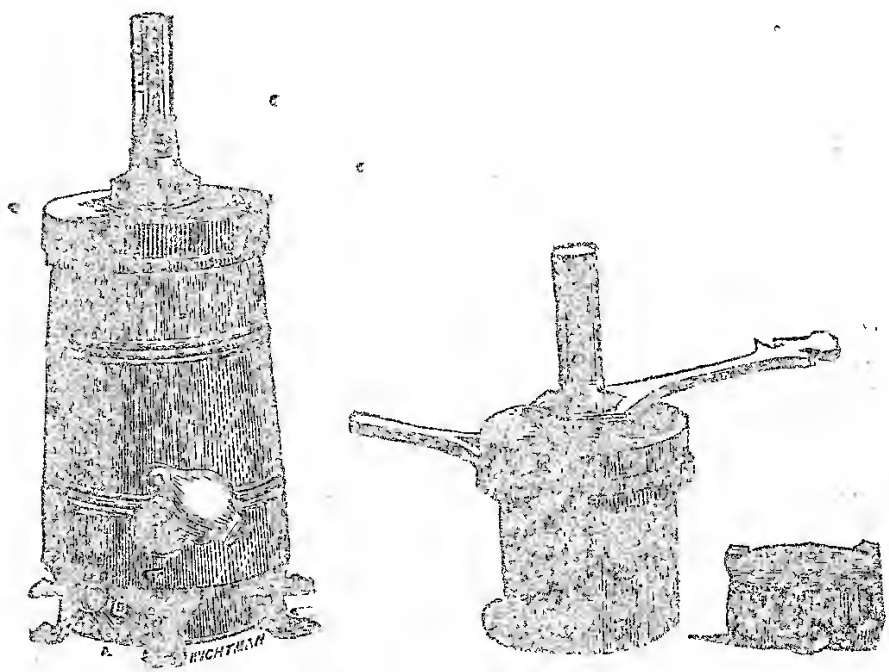


Figs. 68, 69, and 70. Hayes's Vulcanizers.

has reached 310° F., and giving strict attention to the rise and fall of the mercury, the stopcock may be so accurately arranged that the mercury will not

vary more than one degree during the whole time allowed for vulcanizing.

Figs. 68, 69, and 70 represent the "iron-clad" vulcanizer introduced by Dr. Hayes for one, two, and three flasks respectively. The boiler itself is made of copper, and it is surrounded by a jacket or sheath of iron; the copper alone, therefore, is subjected to the corroding influences acting within the



Figs. 71 and 72. Whitney's Vulcanizers.

chamber, and should an explosion take place as a result of the thinning of the copper, the iron sheath which has not suffered deterioration remains of a strength sufficient to resist many times the force exerted by that explosion.

The Whitney vulcanizer having space for from one to three flasks (Figs. 71 and 72) is made of wrought

copper, and the lid, which is screwed on, is provided with a fusible metal plug as a security against explosion.

Thermometers.—Great care must be observed with regard to these, since the least defect in the tube may cause a serious mishap. Indeed so liable are

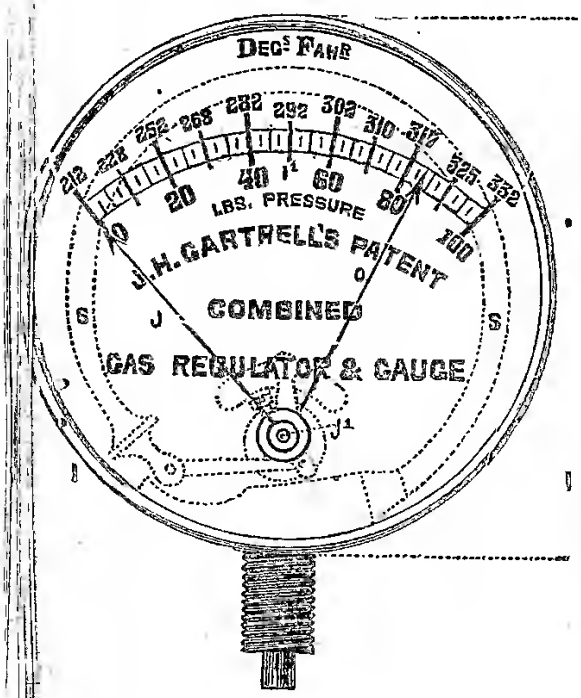


Fig. 73.

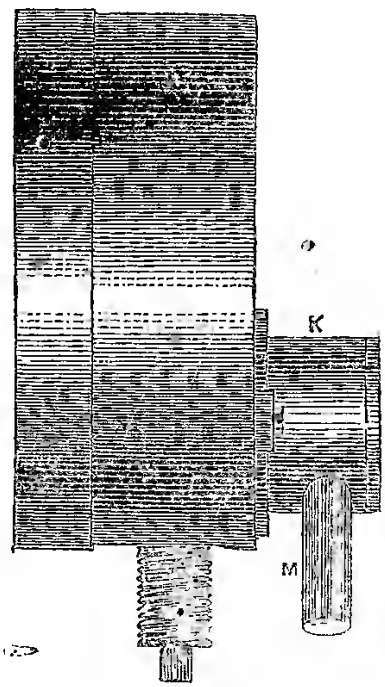


Fig. 73A.

thermometers to become deranged, and so readily may their defects pass unobserved, that a constantly increasing number of dentists are now having their vulcanizers fitted with a steam-gauge in preference to using a thermometer. Since the publication of the first edition of this work gauges of an improved description have been introduced with special regard to the requirements of the dentist. The

best of these for dental purposes we believe to be Gartrell's Combined Gauge and Gas Regulator which is here (Figs. 73 and 73A) represented. Fig. 73 gives a front view, Fig. 73A a side view of the gauge. The advantage of this gauge is, that having set the regulator hand to the point at which you wish to vulcanize and the gas being lighted, the only attention which the vulcanizer requires from the operator is to note the time when the gauge hand reaches the regulator hand. No adjusting of the gas is required, and no further attention, as this machine automatically regulates the gas, and maintains the heat without variation at the vulcanizing point for any length of time. The finger o (Fig. 73) is set to the pressure desired to work at by turning round the gas chamber K (Fig. 73A).

Vulcanizing.—This is a process which demands the most careful attention. The principal point in connection with it, and one which should be thoroughly realised, is, that short time and high heat is ruinous to the best properties of the vulcanite in all cases and the cause of complete failure in many. A disregard of this fact will result in vulcanite pieces which are neither strong nor elastic, and therefore requiring strengthening plates or wires, which are not required in carefully fired vulcanite pieces. Professor Wildman says, "To insure success and produce the best results in hardening any kind of rubber, the heat should be *gradually* raised to the vulcanizing point—not higher than 320° F. —because the best rubber may be rendered worthless by the quick process and vulcanizing at a high

range of temperature." Dr. Franklin says, "If one hour is taken to raise slowly to 300° and another full hour to raise steadily and gradually to 320°, five minutes longer will complete the vulcanizing." This is not a "time" which it would be proper to give in all cases, but it indicates the condition considered by the writer as essential to success. "As thermometers," says Professor Austen, "vary much, and the rubber used also varies, the best plan is for every one to vulcanize trial pieces until the required hardness, toughness, and elasticity is obtained. The vulcanite should curl under the scraper like horn, *permit bending to an angle of at least* 45° *and return to its original shape unchanged.*" Such are the opinions of careful and competent experimenters upon what is required in order to produce the best results in vulcanite work; and the same conclusions must have been forced upon every one who has reflected upon what has happened within his own experience.

The time allowed for vulcanizing must also be proportional to the thickness of the piece and the purity of the rubber. A thick lower made of any of the brown or black rubbers requires the longest time of all. For some of these from one to two hours should be allowed to raise the temperature from 240° to 315°, otherwise such thick cases will be porous or burnt. The same pieces made of gum rubber, on the other hand, may be vulcanized without chance of burning in a much shorter time; that is in consequence of the large amount of earthy matter which the latter contains. Where it is impossible to give the long time required for a thick lower,

it should be made of a gum rubber altogether—S.P. being a good rubber for such cases—or the gum rubber should form the facing and the *core* of the piece, the red forming a more or less thick lining round the lingual surface.

When the flask is taken from the vulcanizer it must be left in water until perfectly cold. The clamp having been removed, a knife may then be carefully used to prise it open at the main joint; the case will generally be retained—opening the flask in this manner—in the upper part; the lid must then be removed; and the best way to get out the piece is to insert a strong-bladed plaster knife between the plaster and the wall of the flask, using the latter as a guide to work against, and send the blade through; repeat this round about two-thirds or three-fourths of the flask, when the plaster may easily be pressed out by the thumb; the cutting away of the plaster from about the case is then very easily accomplished. In taking a case out of the flask in this manner, cut along the back wall first, and be careful in sending the knife through—particularly round the teeth—to keep the blade close to the metal of the flask; if it is *carelessly* entered into the plaster the teeth may be broken. With care, however, this will be found the quickest and safest method to adopt, as a rule, in taking a vulcanite case from the flask.

To cleanse the surface of the vulcanite from the plaster, it will generally be sufficient to brush it well with a strong brush and water. The palate surface of a vulcanite case should never be scraped or cut with a graver.

Finishing Vulcanite.—This is done with files, gravers, or scrapers, sandpaper, and sometimes water of Ayr stone, and the "wheel." The iron-teethed wheels, for "scouring down," which were sometimes used when vulcanite was first introduced, are now entirely abandoned as altogether unfitted for the work of the present day, which if properly constructed requires only the edges to be reduced and the general surface to be scraped.

The quickest and most satisfactory method of finishing vulcanite is by using in the first instance graduated files. The edges of the piece having been reduced, go over the surface with a rough "riffler," next with a medium, and lastly with a fine one. An edge tool may have to be used to trim round the artificial teeth. A most convenient tool (Fig. 75) for clearing vulcanite from *between* the teeth may be made from an ordinary steel pen and holder; one of the points is broken off, and the part of the pen thus left is ground on the corundum-wheel or filed into suitable shape; such a tool will be found most convenient for the purpose, as, from the temper and thinness of the steel, it readily does its work, and if caught or fixed between the teeth no risk is run of the latter breaking, since the tool itself breaks more readily. A file point, sharpened, is sometimes used for this purpose; but this is a dangerous tool to employ, for if it should get fixed between the teeth the latter are easily broken by it. After the fine filing the vulcanite may then be gone over with the sharp scraper, or sandpaper may at once be used; next water of Ayr stone, and lastly the "wheel." The process at the latter

Fig. 74. Riffler.

Fig. 75. Cutting Tool, for finishing between the teeth of Vulcanite cases.

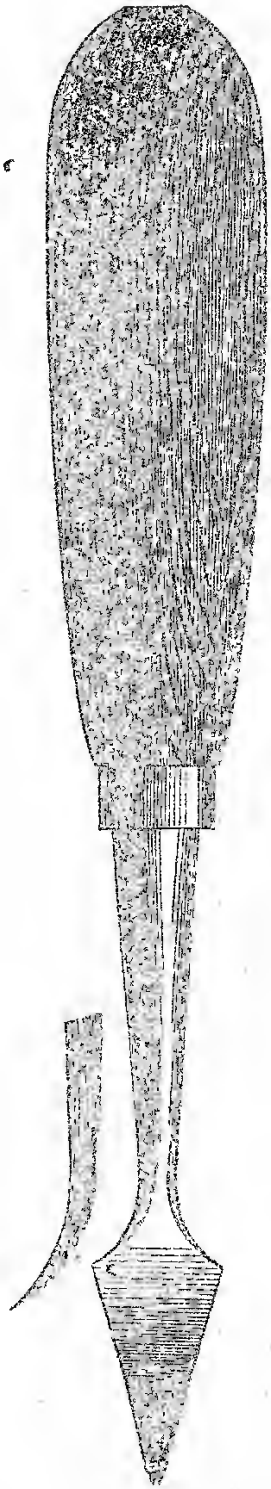


Fig. 76. Scraper for Vulcanite.

is the same as that described for plate, with the exception that, instead of using rouge on the finishing wheel, a mixture of Spanish whiting and rouge, and sometimes the whiting alone, is preferred for vulcanite work.

UPPER SETS RETAINED IN THE MOUTH BY MEANS OF RIDGES.

This method of securing upper sets (complete and partial) was explained by Mr. Evans in the *British Journal of Dental Science* for December, 1874.

On each side of the middle line of the palate, and between the latter and the top of the ridge, a line running parallel with the ridge is found softer than the surrounding parts. This results from the conformation of the hard bone underneath, which along this line is sunk beneath the common level. Mr. Evans takes advantage of this part by attaching ridges to the palate surface of the denture, which after a few hours' wear sink into the palate along this soft line. The accompanying figure shows in section the conformation referred to; *a a* mark the situation of the line along which the ridges should be placed. A wire rather thicker than pin-wire *flattened* represents a ridge which could be used in some mouths, in others a less bold one must be employed. But it is better to make the ridges of full size as they can very easily be reduced afterwards as desired. The part of the palate referred to will be readily discovered by trying the parts with the forefinger.

For vulcanite cases, cuts must be made along the parts indicated, upon the firing model, of the size which is desired for the ridges. For plates, flattened wire may be soldered upon each side of the palate.

Mr. Evans says, "I usually extend these elevated ridges from about the second bicuspid to the second molar (inclusive), keeping them highest in the middle of their length. Of course some practice is required to judge what height of spur can be borne, but they are easily made lower. It might be objected that some of the palatine vessels and

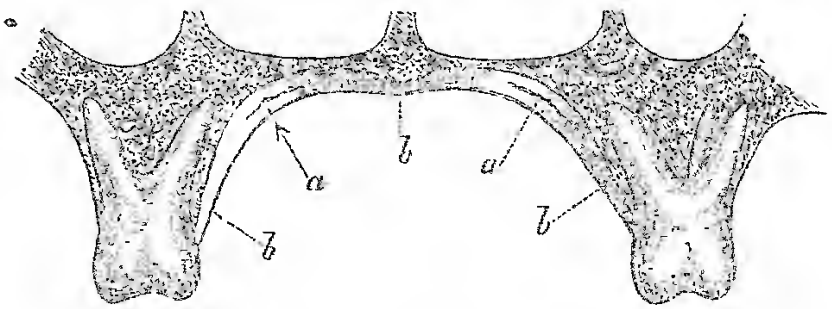


Fig. 77. Section of Jaw, showing the conformation taken advantage of by Dr. Evans for the placing of ridges or spurs upon palate cases.

nerves occupy the groove I have described, and that they might be interfered with, but I have never known such to be the case. And I may further mention, that these plates hold up much better after they have been worn for a day or two." Since Mr. Evans has drawn attention to the practicability of retaining sets in the mouth by this means, many practical dentists have adopted the suggestion, and found the ridge of the greatest value.

CHAPTER IX.

COMBINATION OF GOLD AND VULCANITE.

THIS kind of work may be constructed in one of three ways: 1st, the gold may be struck to the model in the usual way, and be more or less covered with vulcanite; 2nd, the vulcanite may cover the model, and the gold lie upon the lingual surface of the vulcanite; 3rd, the gold may be imbedded in the vulcanite. The following is an example of the first style. A gold plate is struck as explained in connection with gold work, and when it has been perfectly fitted to the model gold "catches" are soldered to the plate at intervals round the ridge (supposing the case is a complete upper); and from this point the case is proceeded with as a vulcanite one. The best method of construction is, after the plate is properly fitted mount the teeth upon it, dressing the wax to exact dimensions. The best position for the "catches" may now be readily observed and marked, by piercing through the *wax* with a broach or otherwise. If the *plate* be now slightly heated, the wax and teeth will come away "in block." The catches are next soldered; three or four are sufficient for a small

upper. They are made of stout plate—or flattened pin-wire may be used—between a quarter and a half-inch long, and, if plate, fully an eighth broad. They should be bent, so that, when soldered to the plate at their middle, both ends will remain free to hold in the vulcanite. To retain them in position while soldering they may be lashed to the plate with binding-wire; the case should be thoroughly heated up before approaching the catch with the flame. These having been soldered, the plate is cleaned in the acid, and afterwards the surface to be covered by vulcanite should be scraped (it is sometimes also "barbed" by a cornered graver to a "rasp" surface). The wax under the teeth should now be excavated where it comes in contact with the catches; the plate may then be slightly heated, and the wax with the teeth, placed in position, the hot knife being used to close the edges. The wax in some of these cases is made to cover the whole lingual surface of the plate, but generally only sufficient is used along the ridge to give a setting to the teeth. In the latter case, when casting into the lower part of the flask, the plaster should be made to quite cover the exposed plate.

For the second method—that in which the gold is placed upon the lingual surface of the vulcanite—proceed exactly as for vulcanite, as far as preparing the case for the flask; when this has been accomplished, the case is cemented to the model, and a sand impression is taken of the lingual surface of the wax plate. A zinc and lead having been procured, the gold plate is struck over the part desired. Upon the under surface of the plate, when it has

been properly fitted and dressed, "catches" must be soldered as described for the former case, though generally of rather smaller size. In order afterwards to secure the strengthener, so that it shall not become displaced in the closing of the flask after packing with vulcanite, a temporary fastening should be soldered to its lingual surface. Wire, somewhat thinner than pin-wire, or a narrow cutting of strong plate, may be used for this purpose. It should be rather more than a quarter-inch long, and bent to a sharp angle close to one end; this short end is clamped to the centre of the plate and soldered, *slightly* (so that it may the more easily be removed when the case has been vulcanized). The long end of the hold which should thus stand at a right angle to the plate should be straight, so that afterwards, when closing and opening the flask immediately after packing, the strengthener may be removed from the plaster and replaced again perfectly in position. Sometimes it may be advisable to solder two temporary fastenings to the lingual surface; in that case they should be soldered so as to lie parallel with each other, with the view as before of withdrawing it readily should that be found desirable.

Before placing the strengthener upon the wax, excavate the latter freely, to admit the catches of the former; by this means it may be placed more accurately in position than if it were simply heated and sunk into the wax. From this point the procedure is of course exactly as for vulcanite. The flasking having been performed according to the *second* method, on opening the flask the plate will

come away with the plaster of the upper part, while the teeth and model remain bound together in the lower. The wax having been cleared and the case "packed" in the usual manner, it will frequently be found advisable, as has already been observed, to remove the plate from the plaster, in order that the flask may be closed in the press and reopened for inspection; before the final closing of course the strengthener is replaced, then perfect closure is effected, the clamp put on, and the case vulcanized.

The third way in which gold or metal may be combined with vulcanite is by imbedding it completely in the substance of the latter. A wire, for example, or narrow plate, may be bent to suitable shape and placed in the centre of the case while packing. Or again, flat teeth are sometimes soldered to a plate which has been struck, not to the gum, but to a thin layer of wax covering the gum; so that in packing the vulcanite may be made to cover the under as well as the upper surface of the plate; the latter should have had a sufficient number of holes drilled in it, and so disposed, that they shall give a good hold to the vulcanite without weakening the gold.

The first method of combination—a simple gold plate struck in the usual manner, with the teeth vulcanized upon it—is a most satisfactory one, and is very generally adopted by dentists. A case made on this principle possesses all the advantages of the simple gold plate, and it may be constructed and finished in much less time.

Plates or wires combined with the vulcanite according to the second and third plans are called

strengtheners. So far as they are meant to give strength to the vulcanite, however, they are altogether unnecessary, unless in a few exceptional cases seldom met with. Some years ago, in consequence of a considerable number of fractured cases occurring, we adopted this system—more especially on the second plan—very extensively, giving nearly every vulcanite case a plate of gold on its lingual surface. The cause of the fractures was, however, afterwards traced to over-firing, and when that error was corrected the vulcanite was found to be elastic and strong, and the strengtheners were dispensed with, as being unnecessary.*

It has been already observed that one of the properties of vulcanite is, that it will permit of being bent to an angle of at least 45°, and return to its original form. But two essential points must be observed in order that this characteristic property of the material may be retained: first, the rubber after packing must be consolidated in a complete manner (for this the press or vice is required); and second, the rubber must be carefully fired at the temperature ascertained to be most suitable for it. If either of these conditions be neglected, then the vulcanite will be weak and untrustworthy.

The wires and narrow plates imbedded in the rubber, as in lower or upper "bridges," are particularly objectionable; as, besides being unneces-

* It is well known that vulcanite does not cling to a silver or even a dental alloy surface, and strengtheners made of these metals are found after vulcanizing to be more or less loose in the vulcanite; if such strengtheners receive a gold surface by the battery process, the vulcanite will then hold, of course, as it does upon a gold plate.

sary, they prevent that elasticity of the piece by which alone frequently these cases can be *inserted* and *retained* in the mouth satisfactorily.

The second method, however—the gold plate on the lingual surface of the vulcanite—is often adopted, simply in order to give a better appearance to the work.

The exceptional cases referred to in which it is necessary to give some kind of plate strengthener to the vulcanite are those which ought to be made altogether in gold, but which for some reason *must* be made in vulcanite. These are generally partial pieces with several artificial teeth standing in an isolated position, and with a close bite. The plate used in these circumstances should be, if possible, combined according to the second plan—placed over the lingual surface of the wax—and the gold should be continued over the ridge into the spaces occupied by the artificial teeth in the form of a tongue, and reaching to within a short distance of the platinum pins. It is at this part of the ridge, which is generally high, that there is the chief danger of the rubber being "worn" by the tongue and opposing teeth, and ultimately giving way.

Although "soldered teeth" in a vulcanite case is a combination most of all to be avoided—on account of the difficulties generally attending the repairing of such pieces and for other reasons—it may occasionally be found necessary to construct a piece in this manner. In such instances the bite comes almost or quite close to the gum and to the back of the artificial tooth: the strengthening plate must then be struck directly to the model,

and the teeth soldered to it in the usual manner; small catches must of course be also soldered to the upper surface of the plate in the position where most vulcanite can be employed to cover them, and the same surface may be "barbed;" sometimes only one or two teeth of a case require to be treated in this manner. Again, a strip of plate may be used, one end being bent up and forming the back of the artificial tooth, while the remaining and larger part comes over the ridge and may be imbedded in the vulcanite.

In all those cases where teeth are soldered to a plate, and the latter is *imbedded* in the vulcanite, care must be taken when inserting the piece in the lower chamber of the flask, where the plaster is brought up in front of the teeth, that the plaster does not come over and *enclose* their points, or the motion which the plate is subjected to in packing and closing the flask, being resisted by the fixed tooth, the latter is subjected to a strain which will probably break it. If the plaster is not brought over to the back of the point of the tooth, then the latter will be capable of the very slight movement which is sufficient to prevent its breaking.

As has been said, this style of work is most unsatisfactory, and should only be resorted to under very special circumstances.

CHAPTER X.

PIVOTING TEETH.

"THIS method of securing teeth was, until recently, on account of its simplicity, more extensively practised than any other, and, under favourable circumstances, is unquestionably one of the best that can be adopted. If the roots on which they are placed be sound and healthy, and the back part of the jaws supplied with natural teeth, so as to prevent those with which the artificial antagonize from striking them too directly, they will subserve the purposes of the natural organs more perfectly than any other description of dental substitute, and can be made to present an appearance so natural as to escape detection upon the closest scrutiny." *

Mr. Tomes, in his "System of Dental Surgery," says "that the root destined to receive the pivot, together with the surrounding parts, should be perfectly free from disease. Hence the most satisfactory cases are those in which the nerve in the root has retained its vitality; and as the operation

* Harris's "Principles and Practice."

of pivoting is only generally applicable to the incisors and canines of the upper jaw, the nerve should be extirpated by a nerve extractor rather than by the use of an escharotic.

"The operation then is commenced by removing, by means of the saw, the cutting forceps, or the file, down to the level of the gum, such portions of the crown of the faulty tooth as may still be standing. The choice of instruments will depend upon the condition of the part to be removed. When the neck of the tooth is strong and sound, the saw may be entered upon each side to within a short distance of the pulp, and the operation of excision be completed with the cutting forceps. If the latter instrument only were employed, a risk of shaking the root in its socket, or of splintering it within the gum, would be incurred. If, on the other hand, the neck of the tooth has been encroached upon by caries, or the crown has been broken off near the margin of the gum, the cutting forceps and the file only will be required, or, perhaps, only the latter instrument.

"The exposed surface of the root must now be cut down with a half-round file to the level of the gum, and even a little below its free edge. The next step in the operation will consist in reducing the pulp cavity to a perfectly cylindrical canal, which should be extended to within a short distance of the extremity of the root. To effect this purpose a five-sided broach may be used, but I have found a half-round drill preferable. From time to time the depth of the hole must be gauged, otherwise the drill may be carried to too great a

depth. I have known the broach passed through the root of a tooth into the alveolus."

The root having been prepared, the artificial tooth must be carefully selected, so as to match the natural ones in colour and shape. The kind of tooth, whether tube or flat, must depend on the position of the cavity in the root, and also upon the "bite." The ordinary tube tooth may be employed if the tubes in tooth and root are continuous, that is if, when the former is fitted and in position, a wire can be passed through both. Besides this the "bite" must be such as to allow a sufficient thickness or strength of tooth to be retained behind; what is known as a close bite would require so much of the back to be ground, to "let up" the bite, that no strength would be preserved in the tooth. Though the cavity in the root and the tube in the tooth may not be exactly in the same line, still, if they agree at the point of union, a tube tooth and gold pivot may be used, as the latter may be bent to an angle which will give the tooth its proper direction. Should the cavity in the root be out of position or the bite be unfavourable, then a flat tooth must be employed.

There may be some cases in which it is advisable to fit the artificial tooth directly to the root in the mouth, but as a rule a small model is taken in the following manner. A piece of copper wire is first inserted in the root; the wire should be about a quarter of an inch longer than the drilled cavity of the latter, and should fit it easily but not loosely. Wax or composition is then placed in a small impression-tray and an impression taken.

Or the tray may be dispensed with, the material being pressed into the space and withdrawn between the finger and thumb. The copper wire comes away with the impression, and is cast with it. When the plaster model is obtained the copper wire is withdrawn, and the hole thus left in the plaster exactly represents the cavity in the natural root.

Tube teeth are most readily mounted upon pivots. The tooth having been fitted to the model to the correct length and position, is then fastened with sulphur upon a piece of gold pin wire which is long enough to form the pivot also, and which has been bent, if necessary, to give the artificial tooth its proper direction. Fig. 78 shows in section a tube tooth mounted on a pivot. Before fastening the wire into the tooth it should be scraped, and barbed or roughened with a sharp graver. The pivot, before inserting the case into the mouth, is generally covered with a thread of floss-silk, touched with mastic varnish.

Fig. 78. Pivot Tooth (tube), in section.

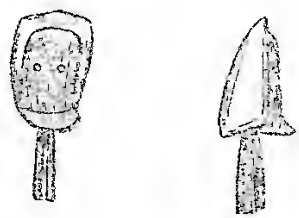
Where a flat tooth is used it is necessary in the first place to fit a small piece of gold plate to the root just sufficient to cover it. This is in most cases easily effected by the pliers, but sometimes a single metal model and counter is used. The position of the root cavity must next be marked on the small plate, which is then drilled or punched for the reception of the gold pivot. To obtain the mark on the plate, insert in the cavity of the root a piece of copper wire, the end of which, filed to a point, appears *just* above the level of the cavity.

This point is tipped with colour, and the plate being brought steadily down into position upon it, the required mark is obtained. The *direction* of the cavity in the root must be noted, and the gold pivot soldered into the plate in that direction. From this stage the method of working is the same as that already described in connection with flat teeth upon gold plates.

Pivot teeth are as a rule inserted in one or other of the ways above described. There are other methods employed, however. Wood pivots are used instead of, or in combination with, the gold ones; or a gold or platinum tube may be fastened into the cavity of the root for the reception of the gold pivot, the latter in such cases being formed of "split" gold pin wire. For those entirely made of wood special teeth are manufactured, having tubes of large diameter. The pivot wood having been consolidated by drawing it through a suitable hole in the draw-plate, one end is carefully inserted into the artificial tooth, and the other is reduced to the size required for the pivot. In using wood for this purpose, the pressure employed either for inserting it into the artificial tooth or the root must be less than that used for gold pivots, as the wood expands after its insertion into the root; if, therefore, it was forced too tightly into the respective tubes there would be some risk of the natural root being split, and also of the artificial tooth giving way. Again, a gold wire having had a thread formed upon it may be screwed into a suitable piece of wood; the latter is then reduced so as to fit into the respective cavities.

The most perfect method of pivoting, however, is first of all to fix a gold or platinum tube in the cavity of the root; a tooth is then mounted upon a "split" pivot, which by its own spring is retained in position. This plan is seldom adopted on account of the time it demands, otherwise it gives most satisfactory results. Richardson says in regard to it, "The best and most approved method of attaching the crown to the root consists in adjusting a metal pivot to a gold tube attached to the root in such a manner that the substitute may be readily applied and removed by the patient. The tube which lines the enlarged canal in the root is constructed and applied in the following manner. A thin strip of gold plate five or six inches in length is first bent round a polished cylindrical steel wire the size of the intended pivot; these are both drawn together through a draw-plate until the gold tube is accurately conformed to the steel rod. The wire is then withdrawn and the joint or seam in the tube soldered; before doing which, however, the joint should be coated on the inside with a mixture of whiting to prevent the solder from flowing in upon the inner walls of the tube. A fine thread is then cut with a screw-plate on the tube, and having introduced into the latter a piece of the steel wire on which the tube was formed, the tube is seized with pliers or a small hand-vice and screwed gently and carefully into the fang. The steel wire is then withdrawn, and the protruding part of the tube removed with a file or cut off with a fine saw." Instead of screwing the tube into the root it may be simply

fitted in and fixed with adhesive gold or amalgam packed round its lower end. To do this, after the cavity in the root has been enlarged to the size required to admit the tube, a burr drill is used to make a sufficiently deep countersink in the cavity; the tube is then introduced and the countersink is packed with adhesive gold. Platinum tubes are sold by the manufacturers for this work, and with them amalgam may be used to pack into the excavation and fix the tube. To make a satisfactory split pin we have found it better to *file* the gold wire half round instead of drawing it, then



Figs. 79 and 80. Pivot Tooth (flat) back and side view.

the two halves receive a thin coating of whiting on their flat surfaces, excepting about an eighth of an inch at one end, which must be left perfectly clean. The halves are then closed accurately together, and the small part at the end—untouched by the whiting—is soldered; this latter part is of course inserted and soldered into the plate, which—for flat teeth—is fitted over the root. Thus, when the case is finished, the split pin may be slightly separated, and its spring will retain the substitute perfectly in position. Fig. 79 shows a flat tooth mounted with a split pivot; Fig. 80 gives a side view of the same.

CHAPTER XI.

REPAIRING.

Gold Plates.—In the case of a plate with flat teeth, to which a tooth is to be added, the most satisfactory method is to select at once a tooth most suitable for the space and fit it to the mouth. The plate is then prepared by filing down any collar or clasp which may encircle the space to be filled, and otherwise making the joint suitable for soldering. The tooth is "backed," and a small piece of wax having been softened and pressed into the vacancy of the plate, it (the tooth) is then fixed in position upon the latter with cement or wax. In order to attach the teeth firmly to the wax and plate, so that slight alterations may be made as to length and direction while the case is in the mouth without loosening them, it is necessary to have the main plate perfectly dry and slightly heated when adding the wax; the plate back of the tooth should also be heated, so that on touching it with wax the latter will be melted and a coating be left on the surface of the back. The tooth is then placed in position, and a hot knife passed down between the parts will effectually secure

them. If these precautions are not taken, some annoyance will be experienced from the teeth dropping from the wax while the case is being tried in the mouth.

When the position of the tooth with respect to circle and bite, &c., is ascertained to be correct, the case is removed from the mouth and at once imbedded in the investient in the usual manner; when the latter is hard and the wax cleared away, the space which is found between the back of the tooth and the main plate must be filled by a small piece of plate closely fitted. In soldering these cases particular care is required, for if the flame be made to solder one joint before the other, the small added plate will probably rise out of position. Thus if the joint made by the main plate with the small one be soldered first, the latter will be drawn up more or less from the back of the tooth, and if the joint made with the tooth back be first soldered, the added plate is then drawn up from the main one. To prevent this the parts must be soldered as far as possible simultaneously; heat one joint just sufficient to "sweat," but not to flow, the solder, then turn the flame upon the other; the sweated solder of the one part fixes it sufficiently to resist the tendency to "rise" while the other is being soldered.

The teeth, instead of being backed at the stage mentioned above, may have the backs put on after the case has been placed in the investient and the wax removed. This plan is practised in all cases by some dentists, but the other is generally preferred.

This method of repairing or adding to plates may be adopted when several teeth are to be added, provided the surface to be covered by the new plate is not so considerable as to render it advisable to fit the latter by striking it between metal models.

Where the addition cannot be made in the above manner, an *impression* of the parts must be taken in either of two ways. Softened wax or composition, in a small lump, is pressed into the space in the plate which is to be supplied with teeth; the plate and wax are then placed in the mouth, and the latter material is pressed up with the finger, to take the form of the gum, the artificial piece being held steadily in position; the patient may close the opposing teeth upon the wax; thus an impression and *bite* is obtained. The case being then removed with the wax attached, a plaster model is made. The second way of taking impressions in such cases is best where large additions are required. Wax or composition having been placed in a tray, an impression is taken with the artificial piece in position in the mouth; the piece comes away with the impression material, when the latter is withdrawn, and a plaster model is cast of the whole. When this has been obtained, the artificial piece will be found occupying the exact position on the model which it did in the mouth.

The model and bite having been cast, the plate is then taken off and prepared so as to make a satisfactory joint along the line where the new one will join with it. After this has been done it

is again placed upon the model and cemented to it, when a sand impression is taken, which need be accurate only over the surface to be covered by the new plate. This must be cut to pattern and struck so as to fit over the required space and slightly overlap the old plate along the border of union. The teeth are then fitted and backed, and the parts having been cemented together the case is imbedded in plaster and sand, and the after stages are the same as in the case already described. Before placing these repairs in the investient a little wax from a hot knife should be run along the line of joint on the under or palate surface of the plate; when this is done the solder is more readily drawn through.

Large additions are sometimes made by means of vulcanite. A small upper, for example, of a few teeth is made up to a complete or almost complete set by making up the required outline with wax upon which the new teeth are set, and the piece is proceeded with as for vulcanite. The plate in these cases must be supplied with suitable catches for holding the vulcanite securely. This method of repairing is extensively practised; but the difficulty of accomplishing future repairs in all instances where soldered teeth are combined with vulcanite, should an accident happen to these teeth, is a great objection to adopting it.

Vulcanite Repairs.—The same method as that just explained for gold repairs is of course equally applicable for these. The vulcanite having been first "scraped" in the neighbourhood of the space to be filled, is then filed into such dovetails as will

give the best hold for the new vulcanite. Soft wax is then added to the part, and the chosen tooth set and fixed upon it. The wax should be somewhat full at the gum border, and the tooth left rather longer than the neighbouring ones, so that when the piece is placed in the mouth it may be moved in the soft wax to the correct position more easily than if it were short and had to be drawn down; the wax by the same pressure takes the form of the gum. Upon removing the case from the mouth, it may be necessary to apply a hot knife to the wax to secure the tooth in the new position; this must be done with care. The piece is then imbedded in the lower part of a two-part flask, the plaster being brought up over the teeth and vulcanite as well, leaving only the labial surface of the wax exposed.

When the flask is opened and the wax removed by the boiling water, the surfaces to be covered by the new rubber should be thoroughly scraped before packing.

Where large additions are to be made to a vulcanite piece, the same methods as regards taking the impression, &c., may be adopted as that explained in connection with gold repairs.

To Reset the Teeth of a Vulcanite Piece.—It is sometimes necessary to take the teeth out of a vulcanite piece and reset them on a new plate and to a new model, while they must occupy the same position exactly with respect to height and projection as before.

In such cases, before removing the teeth from the old piece, cement the latter in position upon the new model, which must be prepared for taking

a bite. The bite, or "circle," as it is called, is made by covering the points and crowns of the teeth over with the plaster, which should also be brought partly over their faces; otherwise it is constructed as an ordinary bite. After this has hardened and been separated, the vulcanite piece must then be thoroughly softened in boiling oil or over the gas-jet when the teeth are extracted, and thoroughly cleansed. The four or six front teeth are next placed accurately in the sockets left by their points in the plaster circle, secured if necessary by a little cement. A wax plate having been made for the model, the circle with the teeth attached is closed upon it, and the teeth are secured at their necks to the wax plate; the circle is then removed and the wax filled in upon the backs of the teeth. The bicuspids and molars are then mounted in the same manner. By this means the original position is exactly reproduced in the new set.

Where it is necessary to imitate minutely the outline of the vulcanite gum of the old piece also, we must, besides the "circle" which has been already obtained, take a cast of the vulcanite gum. Make a "parting" cut or groove on each side of the model, and, having oiled the latter and the vulcanite, cast a shell of plaster round model and vulcanite gum. This outside covering must be made in two parts, the line of division being along the centre line between the front incisors. If it was cast in one part of course it could not be removed.

This outside "circle" of plaster is sometimes cast first, and is brought up in front of the teeth as far

as their tips; the "bite" circle is then cast, forming a cap which covers the crowns only of the teeth. When this plan is adopted the method of setting the teeth is changed. The wax plate having been placed upon the model, the outside circles are then adjusted to the latter; the teeth are then placed in their respective impressions in these circles and secured behind with wax, the "bite circle" being used as the guide for their height. As a general rule these outside circles are not used; the "bite" first described, in which the plaster is made to enclose the points of the teeth, is all that is usually employed; for the outline of the gum the eye is sufficient guide to build the wax to a close resemblance of the original piece.

CHAPTER XII.

CONTINUOUS GUM WORK.

IN this kind of work a platinum plate is struck up in the usual manner. Upon this the teeth are set and fastened behind with cement. The case is then imbedded in the plaster and *asbestos* mixture. When this is hard, and the cement has been removed, the teeth are then "backed," and the joints are soldered with fine gold. The piece, after it has been taken from the investient (the bottom or model part of which should be kept carefully for future use), has its lingual surface including the backs of the teeth covered with a mineral paste; the front of the plate also and necks of the teeth are built up with the paste to imitate the natural gums. The whole is then placed in the muffle of a furnace specially contrived for this purpose, and heated until the material vitrifies. Fig. 81 represents such a furnace in which the ordinary fuel is employed; Fig. 82 is a gas-furnace made by Mr. Fletcher.

The substances used for this work may be obtained from the depôts. The muffle furnace in a variety of forms may also be purchased from the dealers; or a "home-made" one may be easily

constructed. Continuous gum work is not much practised in England; but in America, where the system was matured, it is very popular.

For the following details of this process we are indebted to an article on the subject in Dr.

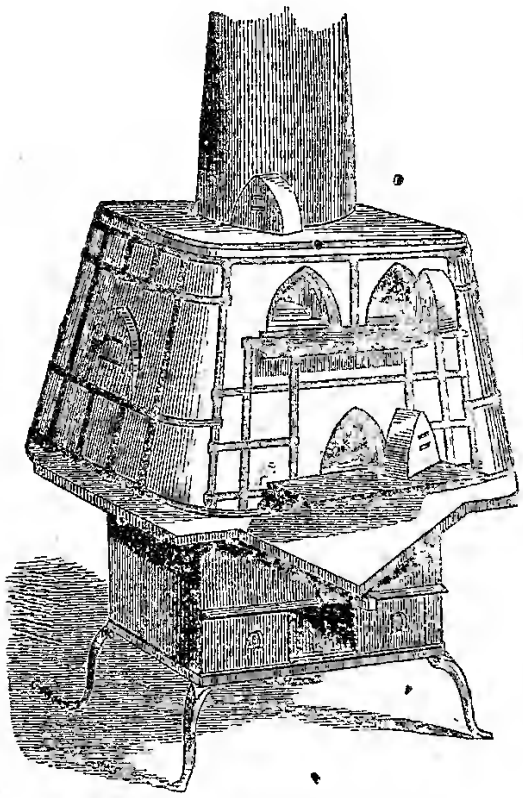


Fig. 81. Muffle Furnace.

Richardson's work, and also to an article contributed by Dr. Roberts to an American journal.

Metallic Base.—"Whenever the porcelain body is united by direct fusion with the metallic base, the latter should be constructed of platinum, as this is the only metal which will withstand the heat

necessary to vitrify the cements in common use. Platinum, both from its infusible nature and comparative exemption from contraction, is admirably adapted to this process; and did it possess the stiffness and elasticity of ordinary gold plate its suitableness would be still further enhanced. It is not improbable that at no very distant period, as before intimated, porcelain cements sufficiently fusible, and possessing otherwise the necessary requisites, will be compounded, justifying the employment of gold alloyed with platinum as a base. At present, gold or its alloys can only be used in connection with this process in those cases where the teeth are united in sections or entire arches independently of the plate base, being subsequently attached to the latter either by riveting or with the use of solder.

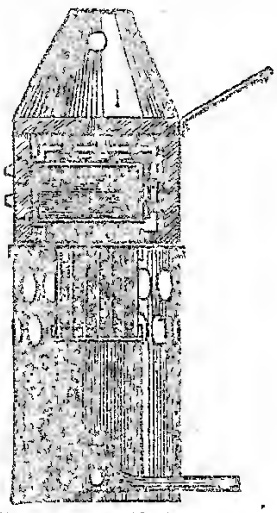


Fig. 82. Muffle Furnace (gas), Fletcher's.

The thickness of plate used will be determined somewhat by the form of the palatal vault and the manner of constructing the metallic base. Ordinarily No. 30 plate may be used; if, however, the arch is shallow and broad, increased thickness should be given to it. On the other hand, if the arch is deep, and marked by prominent rugæ or other sharply defined irregularities of surface, a plate somewhat thinner than that specified may be employed; and if the plate is doubled in the centre, and the space filled in with gum material, plate

No. 32 or 33 will suffice.* In all cases the perfect integrity of the piece requires that the absorption of the ridge shall be complete, otherwise no practicable thickness of a single lamina of platinum will, on account of the soft and pliant condition of this metal, provide perfectly against fracture and deformity in mastication.

It is unnecessary to repeat in this connection what has already been fully described in regard to impressions of the mouth or the manipulations connected with the formation of plaster models and metallic swages, these processes being essentially the same as in the construction of ordinary gold work. Whenever a rim is to be formed to the border of the plate extending from heel to heel of the latter—and this is to be accomplished by swaging—then an abrupt shoulder of plaster must be added to the model along the border where the edge of the plate is desired to be turned up before casting in sand. If it is designed to enamel the entire lingual surface of the plate (a method now commonly practised), the shoulder upon the model should be extended across the heel of the latter from each extremity of the ridge on a line with the posterior border of the hard palate, to form a groove in swaging similar to and continuous with that on the outside of the ridge. The edges thus turned in swaging will flare more than is required; the operation must therefore be completed by carefully turning them over sufficiently with the pliers. In place of swaging the rim, however, it may be formed by fitting and soldering along the border a

* These numbers represent, of course, the American gauge.

narrow plain strip of platinum, extending it as before, if desired, across the posterior edge of the plate. This edge of the plate—that is the lingual edge which crosses the floor of the mouth in an upper case—should always have a narrow strip of the platinum soldered upon it; this leaves a thick edge for the enamel to be dressed against, thus leaving the latter strong and well protected. The outer border of this added rim is of course filed towards the gum. A triangular wire may be used for the above purpose instead of the narrow strip of plate.

In whatever way the rim or socket is formed, it is practically of the first importance that the exact dimensions of the plate required should be ascertained before the groove is formed, as it will be impossible to subsequently diminish the extent of the borders without to some extent impairing the integrity of the finished work. The mouth, therefore, should be carefully examined, and the precise location, extent, and fulness of the muscles and integuments along the external borders of the ridge above and below, the glands underneath the tongue, and the extreme boundaries of the hard palate carefully noted and accurately traced upon the plaster model to serve as a guide in determining the dimensions of the paste.

Zinc and lead are particularly destructive to platinum where the two are heated together, therefore after swaging the plate should be carefully pickled in nitric acid.

The ordinary flat or vulcanite teeth may be used for this work, and they are mounted and fastened

with the cement behind, as already described in connection with other work. They should not, however, be fitted accurately to the plate, but should be set upon a layer of wax; the spaces thus left between the bases of the teeth and the plate will afford a hold to the enamel afterwards to be used.

The case is then imbedded in a mixture of equal parts of plaster and asbestos as for ordinary soldering. When this hardens the cement is cleared from the backs of the teeth, which are then ready to receive their linings, or backs, and attachments to the plate.

Lining the Teeth.—The method of attaching the teeth to the plate by means of stays or linings will depend somewhat upon the construction of the teeth manufactured expressly for this process. They are formed usually with two or more platinum pins or rivets, but those known as "Roberts's teeth," having but a single long pin, require a different application of the stays from those commonly used. The method of lining the ordinary or double-pinned teeth will be first described. A strip of platinum, equal in width to the tooth to which it is applied and one-half of the spaces next adjoining, is pierced to receive the platinum pins, the end resting upon the plate being split into several sections and bent at a right angle with stay, extending back upon the plate an eighth of an inch. The portions of the lining which extend beyond the sides of the teeth are slit even with the sides of the tooth about half-way down from the top of the stay. The linings are thus separately formed and adjusted

to each tooth, and when applied are fastened by pressing the pins together with pliers, while the lateral strips are doubled upon each other and interlocked, thus uniting them throughout.

In the use of teeth having but one long pin their attachment is effected by fitting a strip of platinum plate underneath the pins, extending continuously from heel to heel of the plate, the lower edge resting upon the latter. It is best first to fit a strip of sheet lead to the curvatures of the teeth and to the surface of the plate, to be used as a pattern in cutting out the platinum band. The strip is sometimes formed in sections, in which case they should be united by interlocking the ends. In order to strengthen the attachment this band may be doubled or wired, or additional strips of platinum or pieces of wire may be placed continuously or at intervals along the points of contact between the band and plate. When adjusted it is fixed in place by bending the pins down over it, the band being previously perforated with numerous small holes through which the gum body passes, binding the several parts more perfectly together.

Soldering.—It should be remembered in manipulating this work that the appropriate and only solder for it is *pure gold*. The teeth lined, small pieces of this metal are applied at all points to be united, each piece as it is applied being touched with borax ground in water. The gold should be applied in sufficient quantities to unite perfectly all the parts, and may be confined within certain limits, when fused, by scoring the surface of the plate with a sharp instrument immediately inside

of the linings, or wherever it is desired to limit the flow of the solder. The piece is now placed in the muffle of the furnace, and the heat raised on it till the gold flows, when it should be immediately withdrawn and placed in a cold muffle to cool gradually, the end of the latter being closed. Or the piece may be removed at a red heat from the furnace and soldered with the blowpipe in the ordinary way. When cold, the external covering of the investient is cut away, leaving that portion uninjured on which the plate rests, to serve as a base for the plate in the process of baking the body. The plate and teeth separated from the plaster, are now immersed in a dilute solution of nitric acid, where they are allowed to remain until all adhering particles of vitrified borax are removed, after which the piece is thoroughly washed. To insure a more perfect adhesion of the body to the plate, it is recommended, after having placed the plate upon the die, to scratch or etch with a sharp-pointed instrument the entire lingual surface of the platinum base. The piece is now ready for the application of the gum body.

Application and Fusion of the Body or Base.—The material for the base or body is mixed with sufficient water to form a paste, the portion first applied being sufficiently thin to admit of being worked perfectly into all the minute crevices or interstices around and underneath the ends of the teeth, and about the platinum linings, and into the contracted fissure or groove formed by the rim. When these interspaces are filled in as perfectly as possible, the redundant water may be taken up

partially by applying to the paste, wherever practicable, small pieces of tissue or bibulous paper, when the paste, thus partially deprived of its water, should again be worked in and impacted as perfectly as possible with small, sharp, straight, and curve-pointed knives or spatulas. Before filling in with the body into the more open spaces between the roots of the teeth, the former may be partially filled up with fragments of the crowns of broken teeth, around which and the roots of the teeth the porcelain paste, now used much drier and thicker than at first, is packed as hard and solid as possible. Small portions are thus added from time to time until the required fulness of the gum between and external to the teeth is obtained, drying out occasionally with a clean napkin or tissue paper, and at the same time pressing and patting it with the instrument to drive out entangled portions of air. The paste is likewise applied to the platinum stays, covering them to the depth of from a half to three-fourths of a line, making it fuller as it approaches the plate, and rounding it off at this point with a retreating edge extending back an eighth of an inch or more. If it is designed to enamel the lingual surface of the plate, the gum body should be applied the thickness of a dime to the entire surface continuously with that upon the backings, filling into the groove around the chamber with a uniform surface. The porcelain paste should be carved neatly at the necks of the teeth, and on the exterior or labial surface a shallow concavity or furrow may be formed by cutting out a small portion of the body from between the roots of the

teeth, thus forming a ridge over the fangs of the teeth in imitation of the natural gum. The effect of this carving will be still further enhanced after the application of the gum enamel, which being applied evenly over the surface, a greater depth of gum colour will be imparted to those parts over the furrows, while the intermediate portions over the roots will appear somewhat blanched, or of a lighter gum colour, as in the natural gum.

After the application of the base in the manner described, the crowns of the teeth should be well cleansed with a camel-hair brush of all adhering particles of paste, and the uncovered portions of the plate with a moistened napkin, when the piece should be readjusted to the "plaster and asbestos" base previously used in soldering, placed upon a fireclay slab or slide and introduced first into the upper muffle of the furnace, where it may be allowed to remain exposed to a gradually increasing heat until it is thoroughly dried; when it acquires a red heat it may be transferred to the lower muffle, and the heat urged until partial vitrification of the body takes place, and which may be determined by a slight glossiness of the surface. When baked or biscuited in this manner it may be removed and reintroduced into a cold muffle as when soldering. When the piece is quite cool it must be placed upon a metallic die to detect any alteration in fit, and to restore it to its former shape, which may be done by pressing it down with the hand or by tapping the molar teeth with a wooden or a horn hammer and pressing the plate at the same time firmly down to the die. Should cracks be produced

in the body it is no matter, as these will be filled up in the second baking.

Second Coating.—The paste for the second coating is made the same as that for the first. It is carefully laid upon all the parts that require to be built out, and is introduced into all the crevices into which it is made to settle by lightly tapping the piece. With the little spatula the surface is nicely carved and shaped around the roots of the teeth. A little ridge is raised with a camel-hair pencil from the line between the two central incisors, running back along the palatal surface to the middle of the posterior edge of the plate, and this ridge is next halved by a central line made along its whole length by the brush or the edge of the spatula. On each side of the ridge little prominences are to be raised to imitate the rugæ of the mouth. The second baking must then be conducted like the first (only a little harder), and the cooling also, when the piece should be again placed upon the metallic die in case of alteration in fit. It is now ready for colouring.

Enamelling or Gumming. — The gum, being mixed as was the body, should be laid on evenly and in proportions only to be learned by experience; and in the selection of shades of colour you must be guided by your own taste. I should recommend, however, the use of a very thin coating at first, afterwards a deeper shade can be given by a second coating. If the teeth have been etched in soldering, a little coating of "etching enamel" of the consistency of cream should be laid upon them with a camel-hair pencil. The plate being then cleansed

and replaced upon its investient model is ready for the furnace, but more care is now required not to expose too suddenly to a high degree of heat. If pushed too fast into the muffle pieces are likely to scale off, leaving defective spots such that it would be necessary to remove the work, cool it down, and repair with more gum. When well heated in the upper muffle the piece may be removed to the lower one and exposed to a full white heat for from ten to twenty minutes, or until the gum has thoroughly flowed and shines like melted glass. It is now to be removed, cooled down as before in a cold muffle. When at blood heat take it out, and place it in water of about the same temperature. Avoid touching it with the fingers. This is an effectual method of preventing the checking or grazing of the gum, which frequently occurred in the old way of annealing when the piece was cooled and taken in the hands.

The next and last operation is the polishing. I remove from the plate any little particles of gum or body, and rub it thoroughly with fine sandpaper, then with a fine stick and pumice-stone, and lastly with a steel burnisher or bloodstone with a little soap-suds."

Partial Sets with Continuous Gum.*—"Partial cases may be made with continuous gum; but the work is so various in its nature that the dentist must necessarily depend much upon his own judgment. Difficult cases will constantly present themselves that will require the exercise of much study and

* Dr. Roberts.

ingenuity, and in which the general instructions which can be given in words may be of little service. The first attempt of this kind in my own experience was in replacing two central incisors. Taking two continuous gum teeth, I placed upon them a platinum lining, slitting this down along the edge of the one tooth nearly through the piece, and up the edge of the other tooth by a parallel cut, leaving the two parts joined together by a narrow slit. This allowed sufficient motion between the teeth, so that they could be adjusted as desired. I then placed a bit of tissue paper upon the plaster model covering the spot to be occupied by the teeth and gums to prevent the adhesion of the body to the plaster, and holding the two incisors in their places I worked the body into all the depressions of the gum and around the roots of the teeth. I then removed the whole from the model and placed the piece in a paste of pulverised silex, or plaster and asbestos, and baked as described for full sets. The little slip of platinum kept the two teeth in position. The work shrunk somewhat, but this was remedied by again placing the piece upon the mould with the intervention of tissue paper covered by a thin coating of body. Into this I pressed the piece until it occupied its true place, then filled in again with more body all the crevices around the roots of the teeth, and rebaked.

After enamelling, if the work has been carefully and skilfully done upon this plan, it will be as fine a piece in appearance and fit as can be made. It may then be soldered to a gold plate, and the

little strip of platinum between the teeth be cut out. With the body and gum formerly in use many difficulties were often encountered from discolouration of the gum, or from injuries incurred in soldering. But with Roberts's material these are easily avoided, and the piece can be treated the same as a block or single gum teeth. In partial sets on entire plates of platinum I have sometimes found trouble from the enamel giving way upon the small narrow points that connect the teeth with the plate by the shock, occasioned in biting. I have consequently left these points uncovered, and used two or three thicknesses of platinum to give greater strength. But where this is likely to occur, gold plates would be preferable if nicely adapted with single gum teeth or blocks of continuous gum, as the case might require. I have also applied continuous gum in cases where the natural teeth, from one to five in number, were left in the mouth, by making the plate as in full sets, cutting out around the natural ones, and raising a small bead, or placing a light wire round about one-eighth of an inch or more from the teeth against which the gum or body is to be finished. The points around the teeth are to be left free, in order to be burnished down in case of imperfections caused by the difficulty of obtaining exact impressions in these places. In such cases I have sometimes formed a strong standard of several thicknesses of platinum fitting closely against one or more natural teeth, leaving a loophole through which to run a gold clasp for afterwards securing the artificial set.

I have also secured the gold to the standard by rivets of platinum, and sometimes by two or three gold screws, not providing in these cases the loop-hole. These methods are to be preferred to using solder for fastening, for, in case of repair, the clasps are easily removed without leaving any foreign substance; but in case of soldering, however carefully they may be removed, there will remain some alloy, which in the baking heat to which the piece is to be exposed will be incorporated with the platinum. Even so small an amount of silver as may be in gold coin used for solder will communicate a yellowish tinge to the gum, spoiling the whole work.

Another source of mischief may properly be noticed in this place. In baking, especially with a new furnace or with muffles lately renewed, either at the first or second heat, or it may be in enamelling, the piece is sometimes changed in its texture and colour, as is supposed by the gases present, and the phenomenon is called gassing the piece. The body becomes porous like honeycomb, and of a bluish colour. When this occurs, there is no remedy but to place it upon the metallic die, remove the whole of the injured part, and replace it with a new coating of body and gum. The teeth are seldom, if ever, thus affected. As a precaution, the muffles should be well ventilated with holes for the passage of the heated air and gases.

Repairing.—In case of a single tooth being broken a new one is readily inserted by entirely removing the crown of the injured one, and grinding out a niche in the gum at its base nearly one-

fourth of an inch deep to receive the new tooth; then fill up the niche with body, and press the tooth you wish to insert down to its proper position; trim the surplus body about the neck of the tooth as in full sets, absorb the moisture with a napkin, and apply the gum to the body and wherever required. Stay the tooth with a little plaster and asbestos placed upon its point and reaching over, so as to include the adjoining tooth on each side. A better method, however, is to place the teeth downward, imbedding their points in a paste of pulverized silex laid upon a slide, and then subject the piece to the heat required for enamelling. One baking will generally suffice to complete this operation. But if a piece has been more seriously injured, say by loss of a central canine tooth, with a point broken out from the edge of the gum, and the plate is bent so as to have lost its fit, and the gum shrunken away at any point, we adopt a thorough method of repair. We first take an impression of the mouth and make a plaster model; upon this we place the plate, and over the point where the gum is shrunken we chip off the body and gum, and with a burnisher work the plate down, wherever required, to exactly fit the model. We then make a niche for each tooth to be inserted, apply the body and gum, stay the teeth, and bake the piece as above described. If it has been thoroughly packed two bakings will be sufficient, but sometimes three will be required. The only rule is to repeat the operation till the object is accomplished, taking care always not to overheat the piece. In case of the piece being long worn, it is well, before

doing anything to it, to subject it to a moderate degree of heat, sufficient to burn off any impurities it may have collected in the mouth.

Another set may be presented for repair literally broken to pieces; but the plate remaining a perfect fit, and some of the teeth being undisturbed, we wish to avail ourselves of these. We therefore make a dam of putty around the edge of the plate, and run in fusible metal to form a cast, which shall serve as a support for the plate. Not to endanger cracking the teeth by the heat, the piece may be placed in a dish containing a little water, and after the metal is poured and begins to harden more water may be added, so as to cover the whole mass. But this is hardly necessary if the alloy be run nearly at its cooling temperature.

The piece being now supported upon the cast, and held firmly with one hand, a small chisel made from an excavator may be applied with the other to the old material which it is desirable to remove, and an assistant gently tapping this with a hammer, the body is quickly chipped off between the teeth, and wherever the chisel is directed without injury to other parts, or without misshaping the plate. The teeth may now be inserted and soldered to the plate, with the old or new linings if required, and the new body and gum may then be applied."

CHAPTER XIII.

CELLULOID.

THIS substance is derived from cellulose—the colourless material of the woody fibre of young plants. The cellulose is obtained in the pure state from cotton or linen fibre by boiling out the impurities with which it is associated, with alkali, ether, or alcohol. It is then subjected to treatment with nitric acid, producing dinitro-cellulose, or pyroxylin, which, being dissolved in ether, is known as collodion. The dinitro-cellulose, or pyroxylin, is the chemical compound that is used for the production of celluloid by the addition to it of gum camphor—both being in a finely divided state, and first mixed mechanically. Thus mixed, they are subjected to heat and pressure, when a chemical combination seems to take place, resulting in a homogeneous mass.

For dental purposes the celluloid is supplied in shapes called "blanks." These are in the form of blocks for upper and lower jaws of various sizes.

Though celluloid has been before the dental profession for the last twelve years or more, it cannot be fairly said that it has yet emerged from the probationary period of its existence. It is chiefly in the hands of experimentalists, who, without doubt, during the past few years, have made great advances in the direction of rendering this substance a re-

liable as well as a beautiful base for artificial teeth. But though in the near future celluloid may take an assured position, even to the extent of supplanting vulcanite, it cannot at the present time be said to have the confidence of any considerable number of dentists. And even those who, by their great experience and skill in the manipulation of this material, have been able to produce the best results, speak with some hesitation regarding its complete success.

Mr. Gartrell, than whom no one has done more to perfect the methods by which satisfactory results may be obtained, has kindly furnished us with his conclusions upon the subject. He says: "My opinion of celluloid as a dental base is that it should be used with discrimination. It should not be made for dirty wearers, or those who do not appreciate its colour and appearance. It should not be used for partial pieces, or over roots, unless it is combined with perforated gold or dental alloy, or when the 'bite' is close, as it will not stand the 'wear and tear' of the opposing teeth like rubber. I have a great many cases, full uppers, that have been worn for years without warping. On the other hand, I have a number of cases that have warped. . . . . I have never had a case of warping, however, when I have combined the perforated alloy, or gold, as I have described in book* . . . . In conclusion, I think that celluloid will be used to a limited extent by those who work it properly. And if the material can be slightly improved so as to be harder, less liable to warp and lose its colour,

* "Instructions in Celluloid and Vulcanite."

it will supersede rubber entirely." These conclusions are in perfect accordance with those kindly furnished to the author by Mr. Biggs, of Glasgow, who has also had large experience in celluloid manipulation.

On the Construction of Celluloid Dentures.—It is unnecessary to describe here the mode of mounting the teeth on a wax plate and preparing the case itself for the flasking operation, the process being identical up to this point with vulcanite work. Instead, however, of using plaster models, as in flasking for vulcanite cases, metal models (an alloy of tin and antimony, or tin itself, if pure, being used) are now usually employed in the celluloid process; and where direct pressure upon the model takes place, the advantage of metal over plaster is obvious. The sand used for casting in this instance should be very fine, and rammed tight. The cast should be very shallow. After pouring the metal, and while it is yet fluid, if the mould be tilted over the ladle a shell model is obtained very convenient for flasking; and also one from which a cellulized case, with undercuts, can be detached by crushing the metal upon itself.

The lingual surface of the pattern-plate, and also the gum extending up between the teeth, should be covered with tin leaf about the thickness of writing paper, carefully burnished upon the wax. A smooth surface may be made upon the latter before putting on the leaf by touching it cautiously here and there with the small point of a blow-pipe flame.

The flasking operation is effected precisely as described for vulcanite cases at pp. 105, 106 (the

metal model being retained in the lower part of flask, and the teeth in the upper). The plaster having become thoroughly hard, the flask is placed in a vessel of hot water, opened, and the wax removed in the usual manner. A point requiring special attention here is, that much greater provision must be made for the surplus celluloid than for rubber, and the groove made *must not communicate with the matrix.* This surplus groove, or trench, should encircle the model, its inner circumference should be at all points three-sixteenths of an inch from where the free edge of the pattern-plate reaches, and it should be scooped outwards to the wall of the flask. The groove should be made in that part of the flask which does not contain the teeth.

Packing the Celluloid. — A "blank" being selected of approximate size for the case, it will probably be necessary to saw away portions and fit it somewhat to the mould with a rough file, in order to avoid displacing the teeth on first applying pressure in the machine.

When celluloid was first employed for dental purposes, a very simple apparatus was used for closing the flask. It consisted of a small iron vessel containing oil, which was heated by a Bunsen burner; into this vessel the flask was placed with the "blank" in position; the centre screw, with which the apparatus was fitted, was turned down gently as the celluloid became sufficiently softened by the oil.

This method of working, however, has been discarded. The oil soaking about the celluloid in-

jured the material; and, besides, the necessary conditions for effective heating could not be secured by this means.

An important step was made some years ago by Mr. Gartrell, who invented an ingenious machine similar in appearance and in principle to an ordinary vulcanizer. In it steam is raised to 265° Fah., and while maintained at that temperature the flask is closed by means of a steam-tight centre-screw, which passes into the chamber of the machine, and acts upon the flask. At first little force is required to turn the screw, the finger and thumb being sufficiently powerful to operate the lever; but as the moulding proceeds, the pressure required increases, and at last considerable power with both hands is necessary. The flask, having been perfectly closed, should remain under pressure until quite cold before opening it.

But it now appears to be conceded by all experimentalists in the manipulation of celluloid that steam, like the oil in the previous apparatus, is injurious to the texture of the material when they are brought into direct contact.

The conditions essential to producing a perfect plate are thus summarised by Dr. Flagg, of New York: "(1) No steam, oil, or other foreign substance, must be allowed to come in contact with the material while it is plastic, or it will discolour. (2) During the process of pressing the celluloid, one portion of the blank must not be one degree colder than another portion, or it will warp. (3) The material must have its form changed at a heat much higher than it is now used, otherwise it will

still have a tendency to return to its original position, or, in other words, warp. This superior heat must be obtained in an apparatus that is air-tight, for if the superheated material can obtain oxygen, either in the form of vapour or a current of air, it will surely burn." Various machines have been introduced which more or less fulfil the above conditions.

The "New Mode Heater," invented by Dr. Campbell, appears to be well adapted for producing the best results that can be obtained by this means of manipulating celluloid. The boiler, in this case containing the steam, encircles a dry chamber in which the flask is placed. The latter is closed by a centre screw and three smaller ones, which are worked from the top of the apparatus.* Mr. Gartrell has also designed an apparatus for moulding celluloid under the dry-heat conditions, and, being fitted with his steam-gauge instead of a thermometer, a more reliable indication of the heat in the chamber is obtained.

There is yet another and a later process of filling a flask with celluloid which is spoken very favourably of by Mr. Gartrell and others, viz. the "Injecting Process;" and we believe that by this means, rather than by the system of moulding "blanks," even at the highest possible heat, will the tendency to warping be satisfactorily removed.

The particles of the celluloid having been originally moulded under great pressure into the form of blanks, however we may change these forms under the influence of heat and pressure, if the heat

* Circulars giving full particulars and illustrations of these machines may be had of C. Ash & Son, the Dental Manufacturing Co., &c.

and pressure are not sufficient to entirely transform the arrangement of the particles, the tendency must, we should think, be ever to return to the original form. When the moulding is effected at a low temperature the return is very considerable and very speedy. When, on the other hand, it is effected at a very high temperature, the return, or warp, is very slowly accomplished, and possibly, after some years, the proportion of the warp may be comparatively inconsiderable.

The "Injecting Process" is designed to *entirely* remove all tendency to warping, and it has other recommendations which are obvious. It remains to be proved, however, whether in some essential respects reliable base plates can be made in this manner.

The principle of injecting celluloid, or rubber, is very simple. A special flask is of course required, provided with a passage, or inlet-hole, through the back wall of flask, through which the material is afterwards injected; two or more outlet-holes are also provided.

When the case is placed in the lower section of flask, the heel, or back edge of the pattern-plate, must be on a level with the inlet-hole.

Before filling in the upper section, a wire is pushed through the inlet-hole, and the end imbedded in the wax pattern-plate. This is for the purpose of preserving a clear passage to the matrix. And, for the same reason, wires (or bits of wax taper will do) should be inserted in the outlet-holes, pushing them as far as the wax.

The upper section is then filled in, and the flask

afterwards opened and cleared of wax in the usual manner, and the wires abstracted from the holes. The two parts having then been put together and fastened suitably, the flask is secured by screw-nut

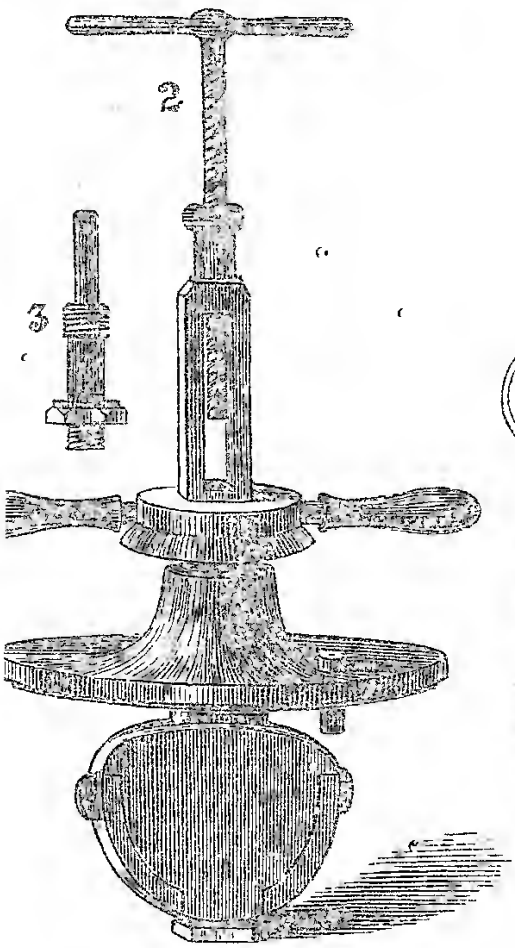


Fig. 83.

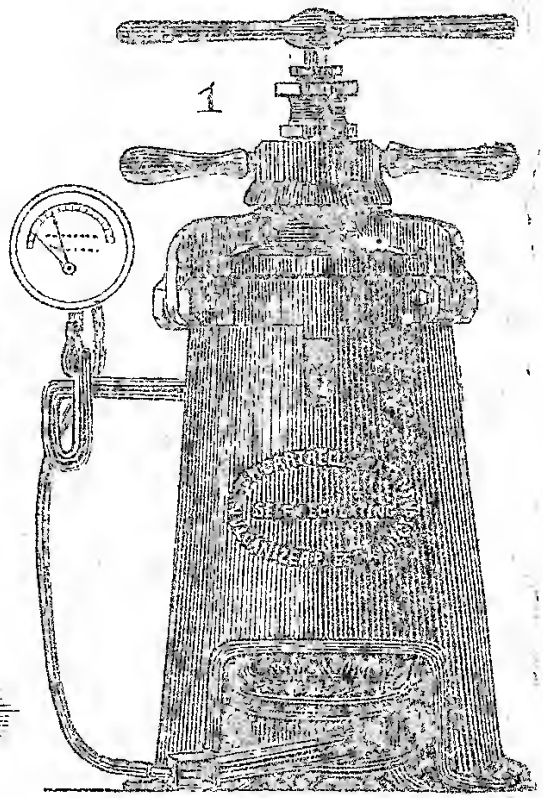


Fig. 83 A.

beneath the piston of the injecting-machine. Fig. 83 shows the injecting-apparatus, in the left-hand drawing, detached from the boiler. The flask is screwed on as described, and the principle of the

process may be readily perceived. Fig. 83A shows the boiler with injecting-apparatus *in situ*.

The rods of celluloid which are placed in the cylinder for injecting, are readily prepared in the following manner:—Take thick 6½ A blanks; saw out the centre, and then place the rim in a vessel of clean boiling water. The cylinder is also dipped in the boiling water, and, with a towel for protection from the heat, is held in the left hand. The celluloid is then taken out of the water and pressed into the cylinder with a twisting or screwing motion; the whole is then dipped into cold water, when the celluloid rod is easily pushed out of the cylinder, and cleaned with a stiff nail-brush, pumice powder, soap, and water.*

Injecting Celluloid into the Mould.—When the heat is near the boiling-point of water, the piston is driven into the cylinder by the screw to compress the celluloid and prevent escape of steam; but it is too soon at this heat to begin injecting the mould; this must be delayed till the gauge indicates 27 lbs. pressure, or a little under 30 lbs.; at this point (at which the regulator hand of gauge should be set before lighting boiler) the injecting is begun by turning the lever a quarter of a turn every fifteen seconds. From twelve to fifteen minutes will pack an ordinary case.

Mr. Gartrell has quite lately designed a more improved apparatus for the celluloid processes. His pamphlets describe in much detail the various stages of the operation, and we, on that account, think it unnecessary to occupy more space on this subject.

* "Instructions in Celluloid," Gartrell.

CHAPTER XIV.

ON THE CONSTRUCTION OF OBTURATORS AND ARTIFICIAL PALATES.

THE palatal organs perform an important part in the production of articulate speech; any defects, therefore, in structure, or any departure even from the ordinary type of formation, is accompanied by an irregularity in the character of the produced sounds more or less marked according to the locality and extent of the defects. In cases of congenital fissure mastication and deglutition are not interfered with to any great extent by the abnormal condition of the parts. Practice, which under such conditions commenced at birth, has no doubt in the course of time developed powers in the surrounding parts which in a great measure compensate for those which are wanting. Besides this, the individual never having experienced a better method in respect to the management of the food, may be said to be unconscious of his misfortune. But in the case of those to whom the defect has come in adult life, discomfort and annoyance are experienced in a very high degree. Therefore in these cases it is necessary for *comfort*, in all cases it

is necessary in order to obtain distinct articulate speech, to close these abnormal openings and to restore as far as possible the functions of the lost parts. To accomplish this by providing the patient with an artificial substitute forms a branch of dental art which has long engaged the attention of the dental surgeon.

The earliest appliance made for palatal defect of which we have any distinct record was that made in 1585 by Ambrose Paré, an eminent French physician. It consisted of a metal plate which fitted over the opening, and to the upper surface of which was fixed a pin with screw; by means of this latter arrangement a piece of sponge was held securely to that surface of the plate next the fissure. When the case was placed in position the sponge passed up into the fissure, and upon absorbing moisture it spread out so as to form upon the superior or nasal border of the latter a kind of rivet which retained the appliance in place. The objections to this description of obturator will be readily understood. The repeated insertion and extraction of these swollen pieces of sponge, which was necessary, injured and increased the extent of the defect. Besides this, the condition of sponge under such circumstances quickly became such as to render the case unwearable on account of its odour. This point was referred to by Laforgue about sixty years ago. He says, "They have always the inconvenience of charging themselves copiously with the fluids, of becoming heavy and falling out of place, and of causing an odour insupportable for the patients and for those who approach them."

Even at the present day, however, this method of securing an artificial palate the dentist is induced sometimes to adopt. Fauchard in 1728 describes a very ingenious appliance invented by him for palatal defects. Instead of the sponge Fauchard constructed on the upper surface of the plate an arrangement of wings. While the obturator was being inserted in the mouth, the wings stood upright so as easily to pass through the opening; when the appliance was in place, the wings were brought down to a more or less horizontal level, thus they lay upon the nasal borders of the opening and retained the plate securely to the palate. This appliance and others contrived about that time injured the natural parts with which they were associated in a very serious manner, and in other respects they were so clumsily fitted to the defective organs, that they were generally recognised to be much more hurtful and inconvenient than useful. About twenty-six years ago Mr. Stearns invented a most ingenious and practically successful description of artificial palate. The principle upon which he acted was, that as the soft parts of the palate are subject to muscular action, any appliance made for these parts should be so constructed as to act in concert with all their movements. By this means what may remain of the soft palate communicates to the artificial velum such motion as enables the latter to perform the functions proper to the parts for which it is a substitute. Figs. 84 and 85 give a view of both sides of this instrument; it will be seen that it consists essentially of two wings which in the drawings

are a certain distance apart along the centre line; a third part is provided, which covers the central slit, but which does not prevent the wings from closing when the edges of the fissure approach each other, as in the act of swallowing. Within the last few years an improved artificial palate has been introduced by Professor Kingsley. The principle adopted is the same as that worked out by Stearns, but the palate itself, which is made of soft rubber, is much more simple in its construction.

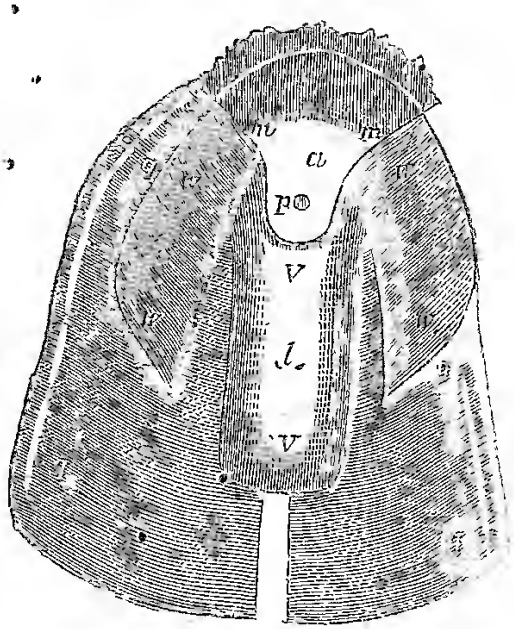


Fig. 84. Artificial Palate (Stearns).

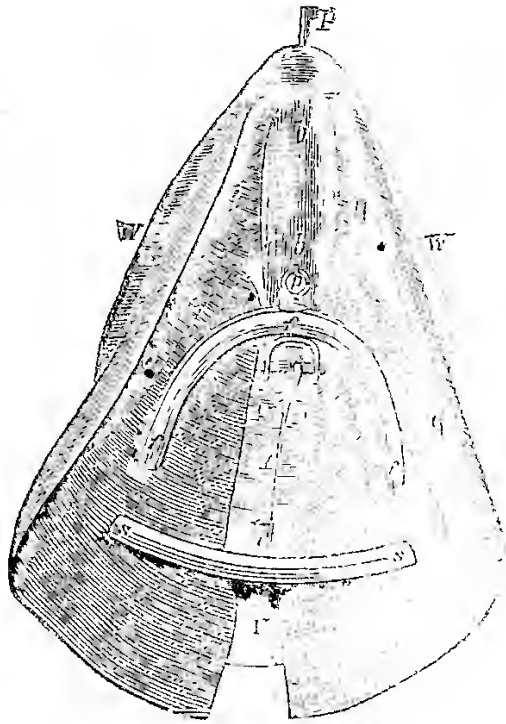


Fig. 85. Artificial Palate (Stearns).

Cases of palatal defect are divided into two classes, according to the immediate causes which may have produced them. First, those

which are the result of arrested development—malformations—are called "congenital;" second, those which are produced by disease or otherwise are called "accidental." A distinguishing feature in the two classes is, that the defect, so far as the palate is concerned, is in congenital cases always in the median line, whereas in accidental cases the defect is generally on one side or other of that line. When the cleft in congenital cases, however, proceeds in an anterior direction, involving the central portion of the jaw and teeth, and ending in fissure of the lip, it then may incline away from the median line in the direction of one or other nasal passage, or it may continue in the median line involving both nasal passages. Accidental defects vary much both as to locality and extent. There may be a simple perforation only of the palate, while in extreme cases, in the opposite direction, the entire soft palate is destroyed, and a considerable portion of the hard palate and jaw with enclosed teeth.

Artificial Appliances.—The two classes of cases being altogether distinct as regards their origin, the artificial appliances made for them ought also to be distinct in their character and structure Such is the opinion of modern practitioners who have had special experience in this branch of dentistry. Thus cases of accidental fissure may be treated successfully with an obturator,* whereas

* The term "obturator" is applied by Dr. Kingsley to all artificial appliances intended to stop a passage, as all openings in the hard or soft palate which have a *complete boundary*. Appliances made to supply the loss of the posterior soft palate, whether accidental or congenital, he calls artificial palates or "vela."

this kind of instrument falls very far short of what is required in the cases of *congenital* fissure. For these an appliance must be constructed which shall not only restore in appearance the lost parts, but will also restore as far as possible the functions which these parts in a normal condition perform. Nevertheless many experienced practitioners do not adopt this system of treatment, but construct for all cases of palatal defect an instrument of a similar character. This is a simple plate made to cover the opening and to restore as far as possible in superficial appearance only the lost parts; the plate for defects in the hard palate is made of the ordinary vulcanite, for those in the soft palate soft vulcanite is employed. Thus it will be observed that the designs of those who advocate the first method have a much wider reach than is the case with those who adopt the second. In the former case the ideal is perfect restoration, in the latter only partial restoration is considered practicable.

The class of "artificial defects" we may subdivide into three species: first, those cases in which there is a perforation of the hard palate; second, those in which the perforation exists in the soft palate: third, those in which there is partial or complete destruction of the soft palate. This classification might be extended to include one or more other kinds, but the treatment necessary for the three mentioned will indicate that which is proper for all. For the first species—perforations in the hard palate—an obturator is constructed which is rigidly fixed to a more or less extensive plate, fitting to the palate and teeth. In the second species of perfora-

tion—through the soft palate—an obturator is also constructed, but in order that the muscular movements of which these soft parts are capable may not be interfered with or controlled by the artificial appliance, this obturator must not be rigidly fixed to the main plate, as in the former case, but in such manner that it will readily take part in all the movements of the parts with which it is connected. For the third species of defect, what is called an artificial velum or palate is required.

Construction of Obturators.—Those openings in the hard or soft palate, sometimes almost perfectly circular, at other times very irregular in form, but always completely surrounded by the natural parts, do not generally present any great difficulty in the course of treatment. It is of importance, in the first place, that an accurate impression be obtained of the opening and of the neighbouring parts of the palatal surface, and also of the teeth, if there are any standing. The only material which gives satisfactory results for this work is plaster of Paris; but in using it special care must be observed, for if an excess of plaster be employed, this excess may in the act of taking the impression be pressed through the opening, and form over its superior or nasal border a rivet of plaster, which may render it impossible to withdraw the model without using such an amount of force as may seriously injure the natural parts. The following method may be adopted in order to prevent the possibility of such a difficulty arising. An impression having been taken with "godiva" in the ordinary manner, is cut to a slight depth over its surface; this surface

is then covered with a thin stratum of plaster, and the impression of the parts again obtained. The small amount of plaster used in this method prevents any such accident happening as that above referred to. Or again, take a wax impression, and make from it a plaster model; upon this form a gutta-percha tray, imbedding in it a piece of wire bent into suitable shape for handle. Into this gutta-percha tray plaster is placed in a thin layer over its surface, and the impression is then obtained without risk. Before covering the surface either of the "godiva" or of the gutta-percha, such portion of the material as may have been pressed into the opening must be removed, and also around the defective part the surface of the material should be reduced slightly, just sufficient to insure that only the plaster will be pressed against these parts when the second impression is being taken. A plaster model having been made from the latter, it is next necessary to form upon the model a pattern in gutta-percha, which will exactly represent the obturator as it is intended to be. The material of which these substitutes are made is now almost invariably vulcanite, and the method of procedure to be adopted in constructing them differs in no very material respect from that already explained in connection with the ordinary artificial work. It must be remembered, however, that as the most perfect obturator would be that one which exactly represented the lost parts, it is necessary in all these cases to construct the work with great delicacy, so that the appliance will as nearly represent the normal outline of the parts as the circumstances

will allow. Thus it will be possible in some cases to make a simple plug, which may be retained in position by being attached to a skeleton plate fitted with clasps. In other instances, however, it will be necessary to cover the whole of the palate—for example, where many or all of the natural teeth are lost. Some dentists do not *fill* the openings in the palate with vulcanite, but carry the plate clear across in a line with its palate border. Professor Kingsley, however, says that it is desirable that the obturator should enter the perforation, to restore, as far as possible, the lost portion of the palate; but it ought not to protrude into or in any way obstruct the nasal passage, the entire freedom of which is essential to the purity of articulation.

Those cases in which the defect is situated in the soft palate require a more complicated appliance than that just described, in order that the motion of which these parts are capable may not be interfered with, which would be the case if the opening was filled by an extension simply of the rigid palate plate.

We have, then, first a main plate, which extends more or less over the hard palate, and which must sit steadily in position; second, we have the obturator or plug fitting into the opening in the soft palate. What is required then is to unite the one to the other in a sufficiently secure manner and yet allow to the obturator perfect freedom to take part in the muscular movements of the soft parts with which it is associated. Several contrivances have been tried in order to accomplish this; the most common of these methods are spiral springs,

band gold, and a simple joint. Of these, the last arrangement is the most satisfactory. The band gold if made sufficiently delicate will not maintain its shape, and if made sufficiently strong for that purpose it is then wanting in the elasticity necessary to permit the perfect motion of the obturator. The spiral spring arrangement is also objectionable, though less so than the band gold. A case constructed with a joint is shown in Fig. 86. The skeleton plate is made of gold, the joint also and the strip of metal reaching to the obturator are made of the same metal. The obturator B is made of vulcanite, and it will be observed that the material enters the opening and forms a flange (C in the smaller figure) around its superior or nasal border. This flange supports the obturator in position, and the joint, which should be placed at the junction of the hard and soft palates, permits the necessary motion.

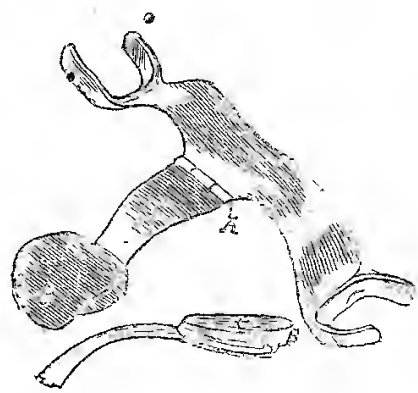


Fig. 86. Obturator attached to Skeleton Gold Plate.

For cases belonging to the third species of accidental fissure—those in which a partial or complete destruction of the soft parts of the palate has taken place—a substitute must be made of a soft and elastic material; the delicate parts with which it must come into contact renders this essential. Soft rubber is admirably adapted for the purpose, and of that material all artificial palates or vela are now made.

Fig. 87 represents a case in which the entire soft palate is gone. Here a substitute is formed very simply by securing an apron of soft rubber along the posterior or palate border of an ordinary set of teeth. Fig. 88 represents the appliance attached. A sufficient number of small holes having been made along the edge of the plate, the at-

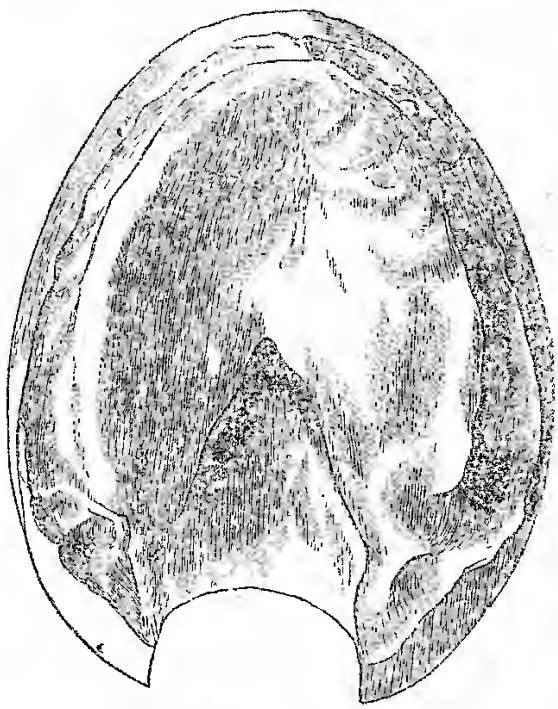


Fig. 87. Model of Defective Palate.

tachment is completed by stitching the soft rubber plate to the other by means of silk or fine platina wire.

In this case, the muscles of the palate being entirely gone, there is no necessity to provide specially for the perpendicular movement of the substitute. Where there is only partial destruction

of the soft palate, however, as in Fig. 89, an appliance is made upon the same principle as that explained in connection with Fig. 86. Fig. 90 shows this palate connected with an upper set of teeth. The following explanation of parts is given in Richardson's "Mech. Dent.," p. 420. "The wings marked A and B are made of soft rubber; the frame to support them is made of gold, with a

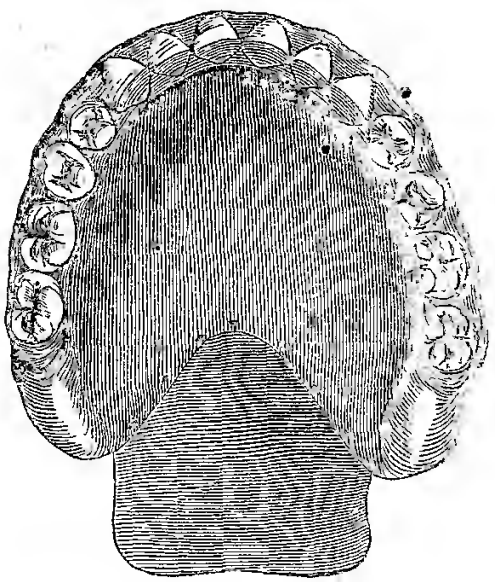


Fig. 88. Artificial Set of Teeth, with palate attached.

joint to provide for the perpendicular motion of the natural palate," as in the case of the obturator represented in Fig. 86. "When the artificial palate is in use, the joint and frame immediately contiguous lie close to the roof of the mouth; the rubber wing, letter A, bridges across the opening on the inferior surface or side next the tongue; the wing, letter B, bridges across the opening on the superior or nasal surface, and is

also prolonged backward until it nearly touches the muscles of the pharynx when they are in repose.

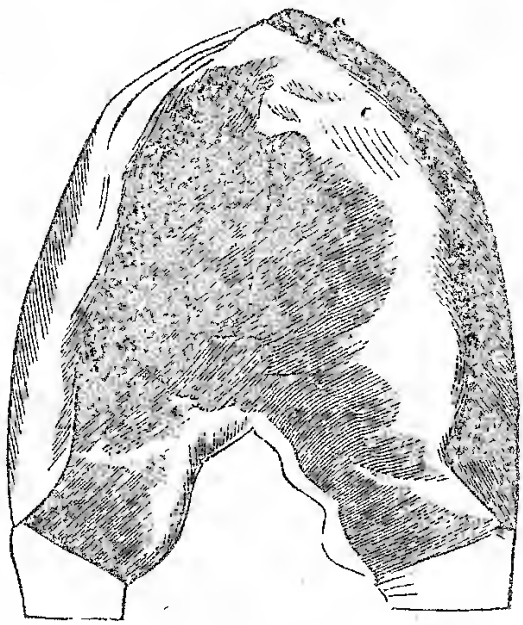


Fig. 89. Model of Defective Palate.

Both these wings reach beyond the boundary of

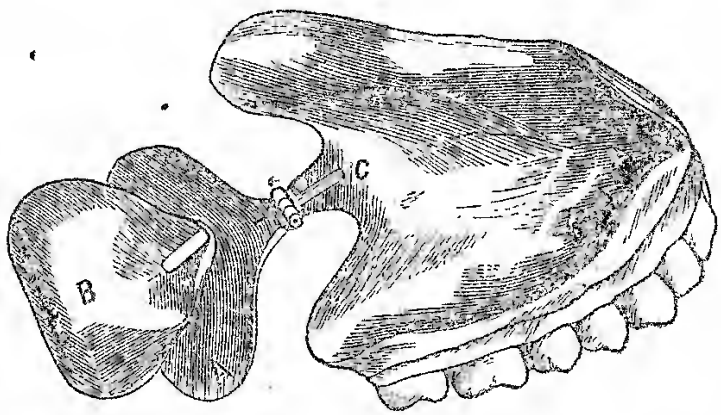


Fig. 90. Set of Teeth and Artificial Palate attached by joint.

the opening and rest on the surface of the soft palate for a distance of from one-eighth to one

quarter of an inch, thus embracing the entire free edge of the soft palate. This last provision enables the natural palate to carry the artificial palate up or down, as articulation may require.

When the organs of speech are in repose, there is an opening behind the palate sufficient for respiration through the nares. When these organs are in action, a slight elevation of the palate, or a contraction of the pharynx, will entirely close the nasal passage and direct all the voice through the mouth. The palate thus becomes a valve to open or close the nares, and to be tolerated must be made with thin and delicate edges which will yield upon pressure. An instrument thus made will restore, as far as possible by mechanism, the functions of the natural organ.

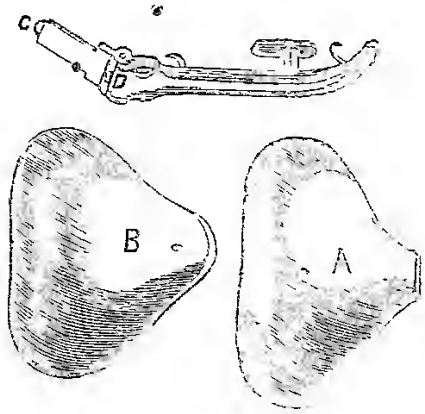


Fig. 91. Parts of which Artificial Palate (Fig. 90) is composed.

In the case under description the patient was a lady. The defect had existed for seven years before remedy. Articulation was very defective; distinct and perfect articulation followed within one month.

Fig. 91 represents the artificial palate separated into its constituent parts. The frame is bent at the joint, in the engraving, to show a stop, marked D, which prevents the appliance from dropping out of position. Letter C shows the tongue, which enters the groove in the plate of teeth and connects them. Letters A and B are the rubber flaps which are

secured to the frame by the hooks, as seen in the engraving."

We now come to consider the second class of palatal defects.

Congenital Fissures.—It has been already observed that many dentists treat these cases practically as those are treated which have an accidental origin. The opinion has long been held, however,

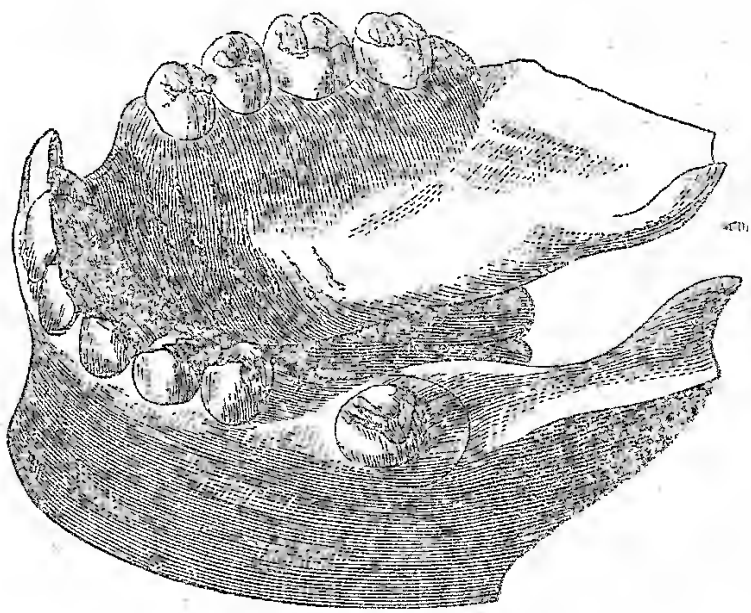


Fig. 92. Model of a Case of Congenital Fissure.

that a different arrangement is necessary—an arrangement by which the parts which have not been developed naturally shall be as far as possible represented artificially, and in such manner that the functions which would have been performed by the natural organs shall be performed by the artificial substitute. This was the principle according to which Stearns constructed his most ingenious

though complicated appliance, by which he provided that the muscular action which arose in the remaining parts of the soft palate should be communicated to the artificial substitute. Thus the natural parts were utilised as a motive power, as it were, to set the artificial material in motion, and make it accomplish the functions of a natural palate.

The Stearns instrument has now been superseded, however, by an appliance made according to the same theory, and which accomplishes the same

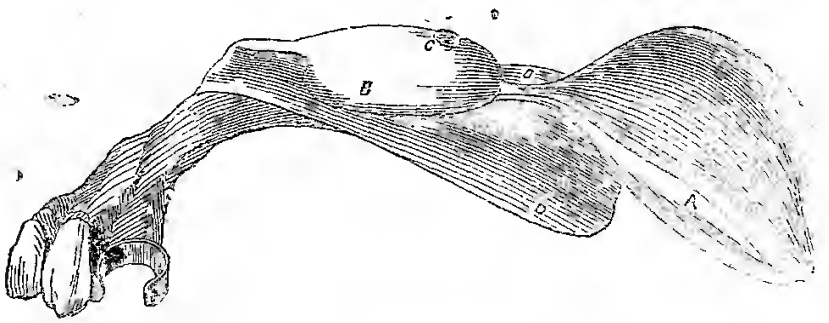


Fig. 93. Artificial Appliance for Congenital Fissure.

object, while at the same time it is much less complicated in its construction. Fig. 92 represents a case of congenital fissure, and Fig. 93 an artificial palate of this description made for the case by Dr. Kingsley.*

Here it will be observed that the letters B, D D, A A, indicate the parts which make up the palate substitute. These parts are made of soft rubber,

* Professor Kingsley, with whose name this description of artificial palate is identified, contributes a chapter upon this subject to Richardson's "Treatise on Mechanical Dentistry" (p. 415). To that chapter we are indebted for the details and illustrations connected with this process.

and the whole may be removed from the main plate, to which the appliance is connected only by the pin C. This pin is securely fixed at one extremity in the main hard rubber plate—which carries the teeth and is continued back under D C in the figure—at the other extremity C the head is considerably larger than the rest of the pin. Now the main plate having been constructed with this up-

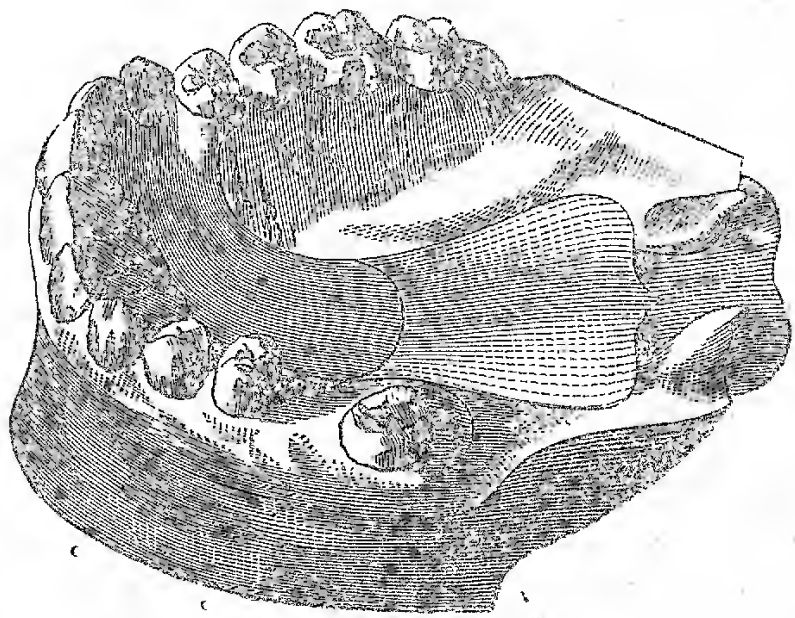


Fig. 94. Artificial Appliance in position upon model.

standing gold pin, and the artificial palate having been constructed with a hole through its elastic substance *exactly* according with the pin in position, but smaller in diameter, the latter is then forced through the hole in the artificial palate, and the arrangement of parts is obtained as shown in Fig. 93. The elasticity of the soft rubber permits the large-headed pin, C, to pass, and at the same

time the contracting force upon the latter is sufficient to fix the parts securely together. The wings D D reach over the inferior or palate surface of the fissure; A A is a similar plate, but more delicately formed, reaching across the pharynx, at the base of the chamber of the pharynx, behind the remnant of the natural velum. These wings, in their relation to the natural parts and to the main plate of hard rubber, will be best observed in Fig. 94. The process B laps over the inferior surface of the maxilla (the floor of the nares) and prevents all inclination to droop.

Method of Construction.—Taking the impression in such cases, it will be at once seen, is an operation which involves peculiar difficulties and which demands special care. Plaster of Paris is the only material which can be successfully employed for this purpose. Professor Kingsley says in regard to the parts of which an impression is necessary, and also as to the method to be employed in order to obtain the impression: "It is essential that the entire border of the fissure from the apex to the uvula should be perfectly represented in the model as the parts are when in repose. It is also necessary that the model show definitely the form of the cavity above, and on either side of the opening through the hard palate, being that part of the cavity which is hidden from the eye. It is desirable also that the posterior surface of the remains of the soft palate be shown, but this is not essential; but it is especially important that the anterior or under surface be represented with relaxed muscles and in perfect repose. The impression for

such a model must be taken in plaster; it is the only material now in use adapted to the purpose. An ordinary Britannia impression-cup may be used, selecting one in size and form corresponding to the general contour of the jaw. This cup will be found too short at the posterior edge to receive the palate, but it may be extended by the addition of a piece of sheet gutta-percha, which must be moulded into such form as not to impinge upon the soft palate, but which will reach under and beyond the uvula, and thus protect the throat from the droppings of plaster. Before using the plaster the posterior edge of the gutta-percha extension may be softened by heat and introduced into the mouth; contact with the soft palate will cause it to yield, so that there is no danger of its forcing away the soft tissues when the plaster is used. With the precaution not to use too much plaster, the first effort will be to get only the lingual surface. After trial, if the impression show definitely the entire border of the fissure, and the soft palate has not been pushed up by contact with the cup, nor pulled up by the spasmodic action of the levator muscles, it is all that is thus far desired. If, however, the soft parts have been disturbed (which on close comparison a little experience will decide), it is better to cast a model into the impression, and upon this model extemporize an impression-cup (in the manner already explained in connection with obturators, p. 183). This temporary cup will have the advantage of the former, insomuch that it will require but a film of plaster to accomplish the result, thus lessening the danger of disturbing the soft tis-

sues. After the removal, if it is seen that any surplus has projected through the fissure and lapped to the floor of the nares, it may be pared off.

The next step will be to obtain, in conjunction with this impression of the under surface, which we will call the palatal impression, an impression of the upper or nasal surface of the hard palate.

This can be done by filling the cavity above the roof of the mouth with soft plaster down to the border of the fissure, and, while yet very soft, carrying immediately the palatal impression against it, and retaining it in that position until the plaster is hard, which can easily be ascertained by the remains in the vessel from which it was taken. With the precaution to paint the surface of the palatal impression with a solution of soap, to prevent the two masses from adhering when brought into contact, there will be no difficulty in removing it from the mouth, leaving the mass which forms the nasal portion *in situ*. With a suitable pair of tweezers this mass is easily carried backward and withdrawn from the mouth, and the irregular surface of contact indicates its relation to its fellow when brought together.

Fig. 95 shows such an impression. The portion marked A B C will readily be distinguished as that which entered the nasal cavity. The line of separation from the palatal impression is plainly indicated. The groove marked D shows clearly the impression made by the delicate uvula in the soft plaster. The nasal portion is relatively large, showing an unusally large nasal cavity.

The vomer lies between the projections marked

A A, these projections entering the nasal passages. The surfaces marked B B came in contact with the middle turbinated bones, the surface marked C in contact with the inferior turbinated bone. In many instances these turbinated bones are so large as to nearly fill the nasal passages."

Casting a model in plaster from the impression is accomplished in a manner similar to that explained in connection with ordinary work, the parts of the plaster marked A B C being withdrawn from beneath towards the back of the model

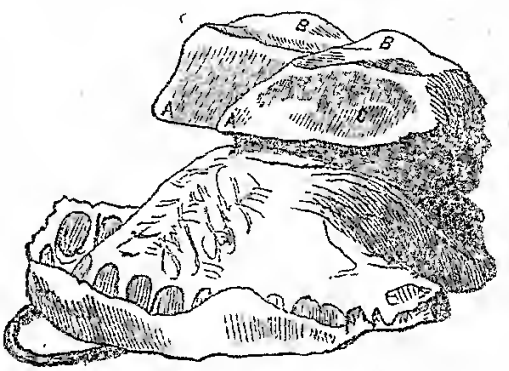


Fig. 95. Plaster Impression for a Case of Congenital Defect.

after casting and separating. The latter should then be somewhat similar in appearance to Fig. 92.

Should the nasal portion of the impression not indicate accurately the superior surface of the soft palate, that part may be carved as near as possible to the dimensions required, the indications of which may be obtained by the aid of a small mirror and probe. It is next necessary to make to the model a pattern of the intended appliance; the best material to use for this purpose is sheet gutta-percha. The form to be given is sufficiently

indicated in Fig. 93. A mistake which is sometimes made is to bring the soft rubber through the opening so as completely to fill the cleft from side to side. By reference to the figures it will be seen that this is carefully avoided. It must be remembered that while the hard palate is incapable of muscular action, and therefore permits us to bring the rubber through the cleft, as at B C, in order to obtain a hold for the case, the soft palate which commences at the posterior boundary of B C is capable of muscular action; the sides, for example, approach towards each other, and therefore only a thin partition of rubber is permissible, in order that that movement may not be interfered with. Other movements besides this one must be provided for by making the wing A very thin and delicate; it occupies the chamber of the pharynx, and is subject to constant muscular movement. "The sides are rolled slightly upward while the posterior end is curved downward. The inferior portion marked D D should only reach to the base of the uvula, and bridge directly across the chasm at this point, and no effort to imitate the uvula should be made. The extreme posterior end should not reach the posterior wall of the pharynx when all the muscles are relaxed by a quarter of an inch, although subsequent use must determine whether this space be increased or diminished, thus leaving abundant room for respiration and the passage of nasal sounds. In cases where it is desirable to make the instrument independent of the teeth as far as possible in its support, the anterior part which occupies the apex of the fissure

in the hard palate may lap over on to the floor of one or both nares. Such a projection is seen in Fig. 93 marked B, and a like process is seen in Fig. 98 but not lettered. Were it not for this process in this case the palate would drop out of the fissure into the mouth, the single clasp at the extreme anterior end not being sufficient to keep the whole appliance in place throughout its entire length. Caution must be exercised that this projection entering the nares be not too large, or it will obstruct the passage and give a disagreeable nasal tone to the voice.

"All these described peculiarities must be provided for in the gutta-percha pattern, which, after having been carefully formed to the cast, may be tried in the mouth to ascertain its length or necessary variations. When its ultimate form has been decided upon, provision must be made to duplicate it in soft rubber."

To make a satisfactory duplicate in soft rubber, type metal models must be used to fire upon instead of the plaster one, as with ordinary work, for this reason: the plaster leaves an unfinished surface, which in hard rubber may be dressed, but in soft rubber can not. Professor Kingsley advises, however, that as it is difficult for a beginner to give the necessary delicacy of form to the gutta-percha pattern, a hard vulcanite pattern piece should be made from the gutta-percha one, using plaster and a flask as in ordinary work; the hard rubber may then be easily dressed to the delicate shape required for the artificial palate. After a little practice in the work vulcanite patterns may be dispensed with.

To obtain in soft rubber a duplicate which will consist of one continuous piece requires a mould to be made of the pattern in four pieces. This is the most desirable form in which to make the appliance, but to make such a mould requires considerable mechanical skill, in order that all the parts may fit accurately together. Therefore Professor Kingsley advises beginners to make the palate in *two* pieces instead of one continuous piece. By adopting this method it can be constructed with

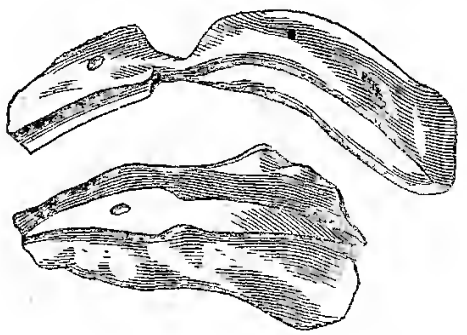


Fig. 96. Artificial Palate made in two pieces.

very little trouble. The mould is also made in two pieces, and, after vulcanizing, the palate pieces are joined.

Fig. 96 shows a palate prepared in this manner.

Fig. 97 shows the mould or flask in which it is vulcanized.

"These flasks," says the same author, "were made expressly for this purpose, but they are not so unlike the flasks in common use in dentists' laboratories that the latter will not answer. The common flask is simply unnecessarily thick or deep.

"The mould is readily produced in the following manner. Imbed the two pieces of the palate in

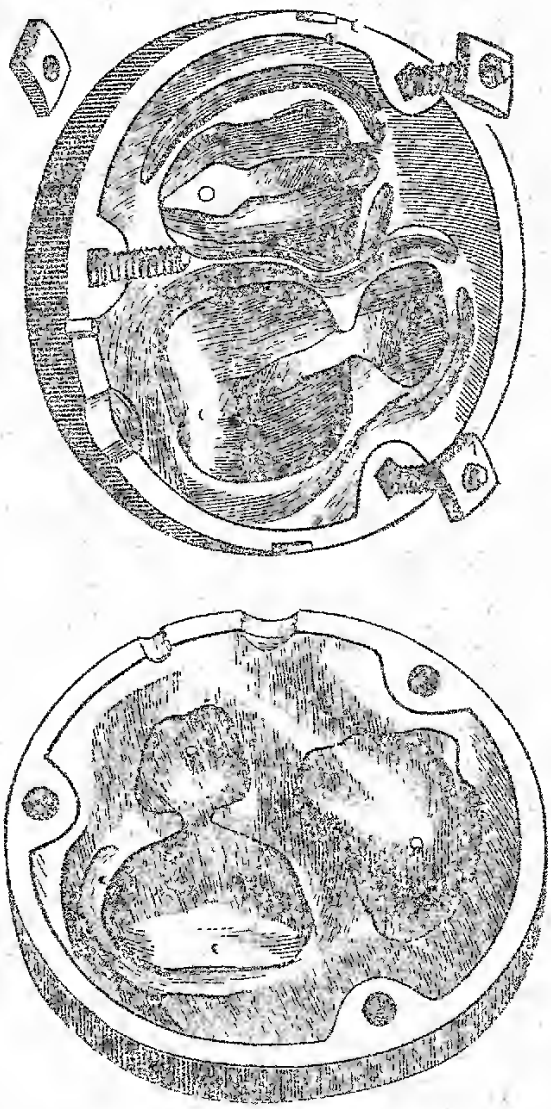


Fig. 97. Moulds in which the Appliance (Fig. 96) is Vulcanized.

plaster in one half of the flask; when the plaster is set and trimmed into form, duplicate it in type metal by removing the palate, varnishing the sur-

face, moulding in sand, and casting. In making the sand mould, take a ring of sheet iron of the same diameter as the flask and three or four inches high, slip it over the flask, and pack full of sand. Separate them, remove the plaster, return the flask to the sand mould, and fill with the melted metal through a hole made in the side or bottom of the flask. With one-half thus made, substantially the same process will produce the counterpart. Fig. 98 shows the palate complete with its attachment to the teeth. The palate is secured to the plate by a pin of gold passing through a hole in

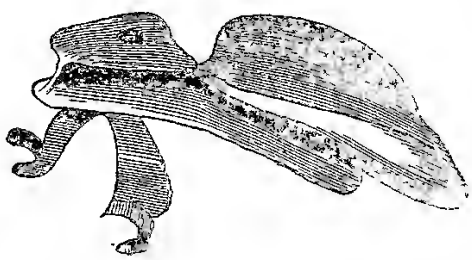


Fig. 98. Appliance completed and ready for insertion.

the palate of the same size, the head on the pin being larger than the hole it is passed through, and thus the two halves of the palate are bound together and joined to the plate.

"Fig. 99 shows a mould in four pieces. The blocks C C are accurately adapted to the body of the mould marked A, and are prevented from coming improperly in contact with each other by the flanges D D, which overlap and rest upon the sides of the main piece. B shows the top of the mould, and the groove E provides for the surplus rubber in packing.

"Such a mould makes the most perfect appliance

that can be produced. The palate is one homogeneous and inseparable piece. The cut will sufficiently indicate the forms of the several parts. Each of these pieces is first made in plaster of

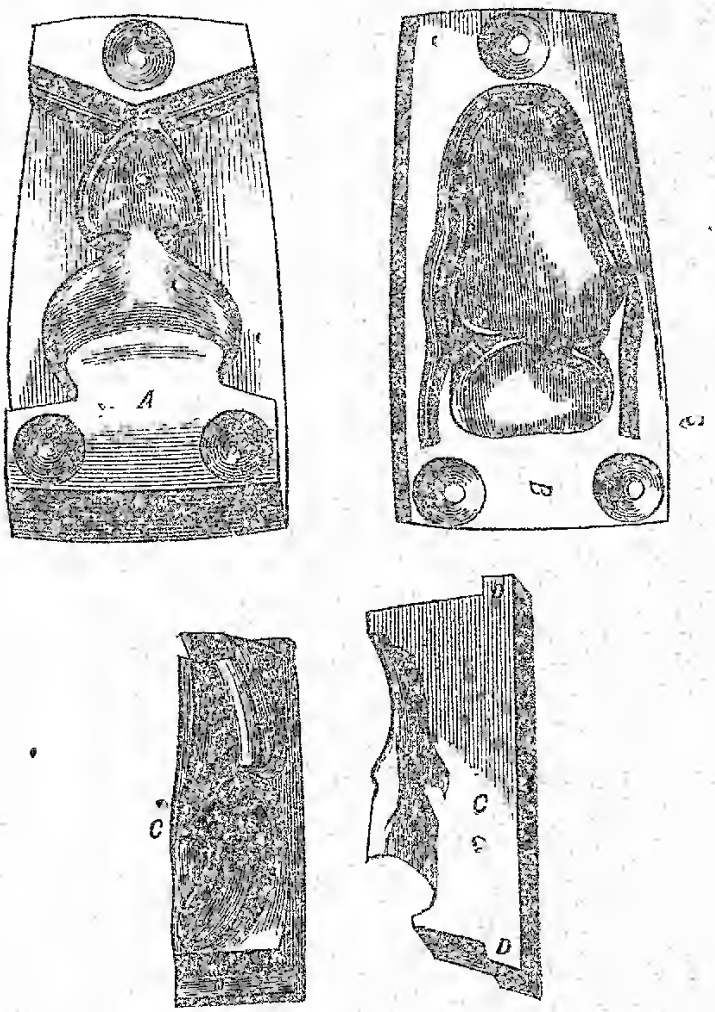


Fig. 99. Moulds required in order to make Palate in one piece.

exactly the form of which the type metal is desired. They are then moulded in sand, and the type metal cast as in making an ordinary die for swaging."

When the parts have been obtained in metal

and *accurately* fitted, it is then necessary to pack with the *soft* rubber in a manner similar to that adopted in ordinary work. If the surface of the metal be washed with a thick solution of soap previous to packing, the palate will be more easily removed after vulcanizing.

The soft rubber which we have found best adapted for this work is that known as "Mr. Ramsey's." It may be purchased at the depôts. Much longer time must be given for vulcanizing this

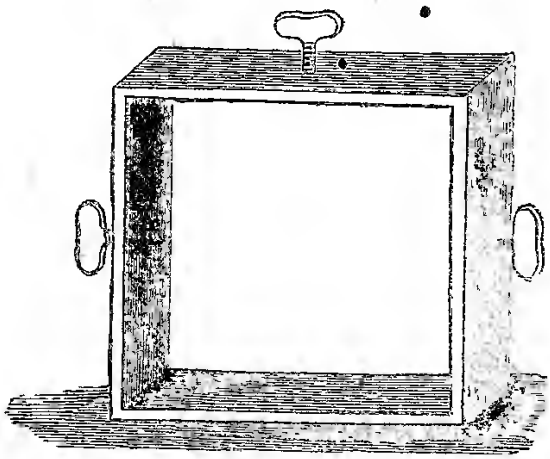


Fig. 100. Frame in which the Mould is held during Vulcanizing.

material than what is required for the ordinary hard rubbers, and the temperature must not rise above 280° Fah. That recommended by Mr. Ramsey is—two hours at 240°, two hours at 260°, and two hours at 280°. In all six hours after the temperature has reached 240°. Dr. Kingsley found that for the soft rubber sold by the American Company the best vulcanizing time is four or five hours, during which time the heat should rise gradually from 230° to 270°.

CHAPTER XV.

VULCANITE.

CAOUTCHOUC, gum-elastic, or india-rubber, occurs as a milky juice in several plants; it is, however, extracted chiefly from the *Siphonia elastica*, which grows in South America and Java. Incisions are made into the bark of the tree, and the juice, which is by this means discharged, is spread upon clay moulds, and dried in the sun, or with the smoke of a fire, which blackens it.

"The specific gravity of caoutchouc is 0·925, and it is not permanently increased by any degree of pressure. By cold or long quiescence it becomes hard and stiff. When the milky juice has become once coherent, no means hitherto known can restore it to the emulsive state. By long boiling in water it softens, swells, and becomes more readily soluble in its peculiar menstrua; but when exposed to the air it speedily resumes its former consistence and volume. It is quite insoluble in alcohol; but in ether deprived of alcohol by washing with water it readily dissolves, and affords a colourless solution. When treated with hot naphtha, distilled from native petroleum or from coal tar, it swells to thirty times

its former bulk; and if then triturated with a pestle and pressed through a sieve it affords a homogeneous varnish, which being applied by a flat edge of metal or wood to cloth, prepares it for forming the patent waterproof cloth of macintosh. Two surfaces of cloth, to which several coats of the above varnish have been applied, are, when partially dried, brought evenly in contact, and then passed between rollers in order to condense and smooth them together. This double cloth is afterwards suspended in a stove-room to dry and to dispel the disagreeable odour of the naphtha.

"The best solvent is a mixture of 100 parts of bi-sulphide of carbon, with from 6 to 8 parts of anhydrous alcohol.

"Vulcanization.—Of all the changes effected by chance, observation, or chemial experiments of late years, few cases have been so important as the change in india-rubber by the process called vulcanization.

"When caoutchouc is mixed with from 2 to 10 per cent. of sulphur, and then heated to 270° and 300°, it undergoes a change, it acquires new characters, its elasticity is greatly increased and is more equable; it is not affected nor is the substance altered by cold, no climate effects a change, heat scarcely affects it, and when it does it does not become sticky and a viscid mass; if it yields to a high temperature it is to become harder, and will ultimately yield at the advanced temperature to char and decompose."*

The first movement towards this new manufacture

* Ure's Dictionary.

appears to have been made in America by Mr. Goodyear, who, having made a contract for india-rubber mail bags, found that they "softened and decomposed in service, and while he thought a permanent article had been made, the colouring materials and the heat united to soften and to destroy the bags; hence by this failure distress of all kinds arose, and the trade was at an end." This moved Mr. Goodyear to make certain experiments. He tried heating the substance, and found it charred like leather instead of melting as gum elastic does, when exposed to a high heat. The idea thus gained was the germ from which the process of vulcanization was derived.

The mixture of sulphur and other substances with the india-rubber was not new, several patents having been taken out in England and America for mixing with these substances, simply in order to get rid of the tendency which the pure or unmixed rubber has to adhere. But no one had any idea that heat would make a further and remarkable change upon this mixed substance, until Goodyear accidentally discovered the new fact. "The general method is to incorporate sulphur with caoutchouc, and submit it to heat; if any particular form is required, the mixture is placed in moulds, and takes off any delicate design that may be upon the metal mould, and if these are submitted to higher degrees of heat, the substance and evolved gases expand, and thus a very hard, horny, and light, but very strong substance is produced, called hard india-rubber, or 'vulcanite.'" The term vulcanization was given by Mr. Brockedon to this process, which

seemed by the employment of heat and sulphur to partake of the attributes of the Vulcan of mythology. For the "change" or "vulcanizing," to get a yielding but permanently elastic substance, steam heat is usually employed in England, but in America ovens with various plans for producing dry heat are generally employed.

TABLE OF ELASTIC FORCE OF STEAM, QUOTED FROM RESULTS OF THE EXPERIMENTS OF THE COMMISSION OF THE FRENCH ACADEMY APPOINTED BY THE FRENCH GOVERNMENT TO INVESTIGATE THIS SUBJECT.

Elasticity of Steam taking Atmospheric Pressure as Unity.	Temp. Fah.	Pressure per sq. in. in lbs.
	deg.	deg.
1	212	14·7
1½	233·96	22·05
2	250·52	29·4
2½	263·84	36·75
3	275·18	44·1
3½	285·08	51·45
4	293·72	58·8
4½	300·28	66·15
5	307·05	73·5
5½	314·24	80·85
6	320·36	88·2
6½	326·26	95·55
7	331·7	102·9
7½	336·86	110·85
8	341·78	117·6
9	350·78	132·3
10	358·88	147
11	366·85	161·7
12	374	176·4
13	380·66	191·1
14	386·94	205·8
15	392·86	220·5
16	398·48	235·2
17	403·82	249·9
18	408·92	264·6
19	413·78	279·3
20	418·46	294

The above table shows that the pressure upon the vulcanizer increases at a much greater rate than the temperature.

	Degrees.	Incr. of Temp.	Incr. of Force per sq. in.	Giving a Force per sq. in.
From	212 to 263·84	= 51·84	22·05 lbs.	36·75 lbs.
	263·84 to 314·24	= 50·40	44·10 ,,	80·85 ,,
	314·24 to 366·85	= 52·61	80·85 ,,	161·85 ,,
	366·85 to 418·46	= 51·61	132·15 ,,	294·00 ,,

Thus we find that while the temperature increased from 263° to 418° at the rate of only 60 per cent., the pressure or force exerted by the steam within the chamber after that increase of heat was at the rate of 600 per cent.

CHAPTER XVI.

METALS USED IN DENTISTRY.

Gold.—(Sym., Au.; At. wt., 19·7).—Gold has now been detected in almost every kind of rock, and in all parts of the world; but it is usually found associated with the older rocks and in the sands of those rivers which pass through them. It is chiefly met with in the metallic state, sometimes crystallized in cubes and its derivative forms. It also occurs in threads of various sizes, twisted and interlaced into a chain of minute octahedral crystals, and in spangles or rounded grains, which are called nuggets when of a certain size. The small grains are not fragments broken from a greater mass, but show by their flattened ovoid shape and their rounded outline that this is their original shape.*

Pieces of gold weighing more than a few ounces have rarely been met with in nature, yet some of considerable size have been recorded. In Siberia, according to Humboldt, large pieces have been found; the largest weighed 27 lbs., and is in the Imperial Museum. A piece weighing 28 lbs. was

* Kerl's "Metallurgy."

found in 1828 at Reid's mines, Cabarras County, North Carolina. In the drift near La Paz, in Peru, a mass 59 lbs. in weight was obtained; whilst in our own colonies one weighing 106 lbs. was dug out of the quartz rock near Bathurst. The latter contained upwards of 91 per cent. of pure gold and nearly 8½ per cent. of silver, being as pure as the English sovereign.*

Physical Properties of Gold.—Pure gold is softer than silver, and possesses malleability and ductility in a greater degree than any other metal. It may be beaten into leaves so thin as to require 251,154 folds to make one inch in thickness. The coating of gold upon ordinary gold lace is yet thinner, because in making it a small cylinder of silver is covered with 1-48th its weight of gold, and drawn into wire which is rolled until 11·8 feet in length weigh but one grain.

Reamur covered a cylinder of silver with 1·360 its weight of gold. It was drawn into a wire, of which 6 feet weighed one grain, and then rolled to a width of 1-48th of an inch, which increased its length to 7·5 feet; and yet the silver was so completely covered that the microscope failed to detect the least appearance of it. The tenacity of gold is less than that of platinum, copper, and iron. A weight of 173·3 lbs. is sufficient to break a wire whose diameter is 0·0784 inch, or nearly 1-13th of an inch. Its tenacity is lessened by hammering, but its stiffness and elasticity are increased. The tenacity may be restored by exposing the metal to sufficient heat.

* Cooley, "Cyclop."

Whilst passing from the liquid state it contracts more than any other metal. According to Berthier the specific gravity of gold after melting is 19·258. This density is increased in proportion as it is hammered, the maximum being given as 19·65.

For a detailed account of the metallurgical process of refining gold, as well as for the methods adopted by the assayer, we would refer the reader to the "Manual of Metallurgy," by Makins, or Ure's "Dictionary of Arts;" a description of the humid process of refining, however, which the dentist might wish to adopt for intractable scrap or lemel, is here given.

To refine Gold by the Humid Process.—To accomplish this the metal must be submitted to the action of either nitric acid or of aqua regia. If it be intended to use the nitric, then the gold must first be melted along with an excess of silver ($2\frac{1}{2}$ silver to 1 part gold), and the alloy should be granulated by pouring the melted metal from a considerable height into a deep vessel of water. The grains having been carefully collected are then placed in a basin or suitable German flask, and treated with nitric acid, as follows:—

Alloy of gold	1 oz.
Nitric acid (sp. grav. 1·3) . .	$2\frac{1}{2}$ to 3 ozs.

The time required for the acid to do its work of dissolving the silver depends upon its temperature; if cold it will require several hours, but if it be heated to boiling the action is very rapid. The fluid, after this has been satisfactorily accomplished, is poured off into a second basin, and the gold may be subjected to the action of a smaller

quantity of fresh nitric acid; this, when it has done its work, is also poured into the second basin; the gold remaining in the first is then carefully washed and dried, when it is placed in a crucible and melted with a little borax; the resulting "button" of gold is then alloyed, melted, and poured, as already described at p. 35.

The silver which is held in solution in the nitric acid poured off, is precipitated by adding common salt, which throws the metal down in the state of white powder. Before adding the salt dilute the acid copiously with water.

The precipitated metal is washed and dried, and melted in the same manner as the gold.

In refining by means of aqua regia the gold requires no addition of silver to be made to it; but it should be rolled very thin, or granulated, before submitting it to the acid. Aqua regia is composed of 3 parts of hydrochloric acid and 1 of nitric. For 1 oz. of gold alloy, use 4 ozs. of aqua regia. The flask is then heated on a sand bath, and when the desired effect has been produced the solution is poured off; and the residue of chloride of silver is boiled again with a smaller quantity of aqua regia, then washed with distilled water and reduced. The gold held in the solutions poured off is precipitated by adding protosulphate of iron dissolved in clean rain-water. "It is to be added gradually to the gold solution as long as a precipitate is found, and even longer, as an excess will the better insure the precipitation of all the gold. The gold thus precipitated is a brown powder, having none of the appearances of gold in its ordinary state,

The solution should now be filtered, or the gold should be allowed to settle to the bottom, where it may be washed after pouring off the solution. It is better to filter than decant in this case, as frequently particles of the gold float on the surface, and would be lost in the washing by the latter process.

"Minute traces of iron may adhere to the gold thus precipitated. These can be removed by digesting the gold in dilute sulphuric acid, and when the process is properly conducted thus far the result is *pure gold*, which may be melted under carbonate of potash, in a crucible lined with borax, and reduced to the required carat." *

"The chloride of silver may be reduced by melting it with carbonate of potash or, better—according to Guy Lussac—with freshly burned lime." †

TO CALCULATE THE AMOUNT OF ALLOY REQUIRED FOR GOLD PLATE.

[The following table is given by Professor Austen, and shows the amount of fine gold in the various carats.]

	Fractions.	Carats.	Decimals.
Pure gold . . .	1	24	1000
English coin . .	$\frac{11}{12}$	22	916·6
American coin . .	$\frac{9}{10}$	21·6	900
Dentists' gold, best .	$\frac{5}{6}$	20	833
,, ,, good .	$\frac{4}{5}$	19·2	800
Jewellers' gold, best .	$\frac{3}{4}$	18	750
,, ,, good .	$\frac{5}{8}$	15	625
,, ,, common	$\frac{1}{2}$	12	500
Commonest solder .	$\frac{1}{3}$	8	333·3

* Prof. Watts, "Dental Register of the West."

† Kerl, "Treatise on Metallurgy."

The table gives the amount of pure gold, subtracting which from the number at the head of each column will give the amount of alloy. For example, the best jewellers' gold contains 18 carats of pure gold; subtract 18 from 24, the number at head of column, gives 6 parts of alloy; or take the fraction column, $\frac{3}{4}$ pure gold and $\frac{1}{4}$ alloy; or the decimals, 750 parts pure gold and 250 parts alloy.

Various formulæ are given for reducing gold from a higher to a lower standard. The following is by Professor Austen: "Divide the lower carat (*c*) by the difference between the lower carat (*c*) and the higher (C); divide the weight (W) of the gold by this quotient, and it will give the amount of alloy to be added. This expressed in algebraic formula is—

$$A = W \div \frac{c}{C - c}$$

Suppose the weight is 20 dwts., the carat 24, it is required to reduce this to 18-carat gold; divide the weight 20 by 3 (which is the quotient after dividing the lower carat by the difference between the lower and the higher), this gives 6 dwts. 16 grs. as the amount of alloy required."

Professor Watt* gives the following formula: "To reduce gold to a required carat, the proportion may be expressed as follows: as the required carat is to 24, so is the weight of the pure gold used to the weight of the alloyed mass when reduced. The weight of gold subtracted from this

* "Dental Register of the West."

gives the quantity of alloy to be added. For example, reduce 6 ozs. of pure gold to 16 carats.

16 : 24 :: 6 : 9

Six subtracted from 9 leaves 3, which is the quantity of alloy to be added. As another example, reduce 1 dwt. of 22-carat gold to 18 carat. As the gold is only 22 carats fine 1-12th of it is already alloy. The 1 dwt. therefore contains but 22 grs. of gold. The statement is therefore thus expressed—

18 : 24 :: 22 : 29⅓

Twenty-two subtracted from 29⅓ leaves 7⅓. Therefore each dwt. of 22-carat gold requires 7⅓ grs. of alloy to reduce it to 18 carats."

To ascertain the Carat of any given Alloy.—As the weight of the alloy is to the weight of gold it contains, so is 24 to the standard sought. For example, take Harris's No. 3 gold solder :—

Pure gold	6 parts.
Pure silver	2 ,,
Pure copper	1 ,,
Total	9 ,,

The proportion would be expressed thus :—

9 : 6 :: 24 : 16

As another example under the same rule take Harris's No. 1 solder :—

22-carat gold	48 parts.
Pure silver	16 ,,
Pure copper	12 ,,
Total	76 ,,

As the gold used is but 22 carats fine, 1-12th of it is alloy; 1-12th of 48 is 4, which subtracted from 48 leaves 44. The statement then is:—

$$76 : 44 :: 24 : 13{\cdot}9$$

The solder therefore falls a fraction below 14 carats.

To raise Gold from a Lower to a Higher Carat.—Gee gives the following. The numeral 20 represents 20 dwts. of gold, which is to be raised from 9-carat to 15-carat. The 15 represents the carat required; the 9 represents *the difference* between the required carat and 24.

$$\begin{aligned} 20 \times 15 &= 300 \\ 20 \times 9 &= 180 \\ 300 - 180 &= 120 \\ 120 \div 9 &= 13 \text{ dwts. } 8 \text{ grs.} \end{aligned}$$

"Therefore to every ounce of 9-carat gold we shall have to add 13 dwts. 8 grs. of fine gold to make 15-carat-gold."*

Supposing we have a piece of gold of a certain carat, and we wish to raise it to a higher one, then the weight of the gold is multiplied by the required carat, also by the difference between the required carat and 24; the difference between the two products is then divided by that between the required carat and 24; the result gives the fine gold to be added.

* "Practical Goldworker" (Gee).

Gold Alloys.

Composition of a sovereign.

	ozs.	dwts.	grs.
Fine gold, per oz.	0	18	8
Refined copper	0	1	16
	1	0	0

Gold plate, 20 carats fine.

	ozs.	dwts.	grs.
Fine gold	1	0	0
Fine copper	0	2	0
Fine silver	0	2	0
	1	4	0

Gold plate, 20 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns	1	0	13
Fine copper	0	0	15
Fine silver	0	1	10
	1	2	13

Gold plate, 19 carats fine.

	ozs.	dwts.	grs.
Fine gold	0	19	0
Fine copper	0	3	0
Fine silver	0	2	0
	1	4	0

Gold plate, 19 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns . . .	1	0	12
Fine copper	0	1	0
Fine silver	0	2	6
	1	3	18

Gold plate, 18 carats fine.

	ozs.	dwts.	grs.
Fine gold	0	18	0
Fine copper	0	2	0
Fine silver	0	2	0
	1	4	0

Gold plate, 18 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns . . .	1	0	12
Fine copper	0	1	9½
Fine silver	0	3	2½
	1	5	0

Gold plate, 16 carats fine.

	ozs.	dwts.	grs.
Fine gold	0	16	0
Fine silver	0	4	0
Fine copper	0	4	0
	1	4	0

Gold plate, 16 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns	1	0	12
Fine silver	0	4	15
Fine copper	0	2	21
	1	8	0

Spring gold, for clasps, wire, &c., 20 carats fine

	ozs.	dwts.	grs.
Fine gold	1	0	0
Fine copper	0	2	0
Fine silver	0	1	0
Platinum	0	1	0
	1	4	0

Spring gold, 16 carats fine.

	ozs.	dwts.	grs.
Fine gold	1	16	0
Fine silver	0	6	0
Fine copper	0	12	0
	2	14	0

Solders.

16 carats fine. Used with 20-carat plate.

	ozs.	dwts.	grs.
Fine gold	0	0	0
Roset copper	0	2	0
Fine silver	0	1	0
	0	3	0

15 carats fine (fraction over). Used with 18-carat plate.

	ozs.	dwts.	grs.
Fine gold	0	6	0
Fine silver	0	2	12
Fine copper	0	1	0
	0	9	12

15 carats fine (fraction over). Reduced from English coin.

	ozs.	dwts.	grs.
Sovereign gold	0	6	0
Fine silver	0	1	17
Fine copper	0	1	0
	0	8	17

The same reduced from 18-carat plate.

	ozs.	dwts.	grs.
18-carat gold	0	6	0
Fine silver	0	0	15
Fine copper	0	0	9
	0	7	0

Harris's fine flowing solders. No 1. Fraction below 14 carats.

	ozs.	dwts.	grs.
Sovereign gold	0	2	0
Fine silver	0	0	16
Roset copper	0	0	12
	0	3	4

No. 2. About 12½ carats.

	ozs.	dwts.	grs.
Sovereign gold	0	1	15
Fine silver	0	0	16
Roset copper	0	0	12
	0	2	19

The two last recipes are objected to by Richardson, as being too inferior in quality for dental work.

Brass or Zinc in Solder.—Richardson adds 10 grs. of brass to the 15-carat solders given above.

TABLE SHOWING THE PROPORTION OF ALLOY TO BE ADDED TO 1 OZ. OF STANDARD GOLD IN MAKING THE FOLLOWING QUALITIES.

Qualities.	Standard Gold.			Alloy added.			Total.		
Carats.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
21	1	0	0	0	0	23	1	0	23
20	1	0	0	0	2	0	1	2	0
19	1	0	0	0	3	4	1	3	4
18	1	0	0	0	4	10	1	4	10
17	1	0	0	0	5	21	1	5	21
16	1	0	0	0	7	12	1	7	12
15	1	0	0	0	9	8	1	9	8

TABLE SHOWING THE PROPORTION OF ALLOY TO BE ADDED TO 1 OZ. OF FINE GOLD IN MAKING THE FOLLOWING QUALITIES.

Qualities.	Fine Gold.			Alloy added.			Total.		
Carats.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
23	1	0	0	0	0	20	1	0	20
22	1	0	0	0	1	18	1	1	18
21	1	0	0	0	2	20	1	2	20
20	1	0	0	0	4	0	1	4	0
19	1	0	0	0	5	6	1	5	6
18	1	0	0	0	6	16	1	6	16
17	1	0	0	0	8	5	1	8	5
16	1	0	0	0	10	0	1	10	0
15	1	0	0	0	12	0	1	12	0

TABLE GIVING THE WEIGHTS OF PIECES OF GOLD OF THE SAME DIMENSIONS, BUT OF DIFFERENT CARAT VALUE.

Qualities.	ozs.	dwts.	grs.
24 carat of given dimensions will weigh	1	0	0
23 " " " "	0	19	12
22 " " " "	0	19	0
20 " " " "	0	18	0
18 " " " "	0	17	12
15 " " " "	0	16	0
13 " " " "	0	15	0
12 " " " "	0	14	12
10 " " " "	0	14	0
9 " " " "	0	13	12
8 " " " "	0	13	0
7 " " " "	0	12	12

From the above table an approximate estimate, therefore, may be made of the value of any piece of gold.

TABLE OF VALUE.

Qualities.	£	s.	d.
24-carat gold, costs per oz.	4	6	0
23 ,, ,, ,, ,,	4	2	6
22 ,, ,, ,, ,,	3	19	0
21 ,, ,, ,, ,,	3	15	6
20 ,, ,, ,, ,,	3	12	0
19 ,, ,, ,, ,,	3	8	6
18 ,, ,, ,, ,,	3	5	0
17 ,, ,, ,, ,,	3	1	6
16 ,, ,, ,, ,,	2	18	0
15 ,, ,, ,, ,,	2	14	6
14 ,, ,, ,, ,,	2	11	0
13 ,, ,, ,, ,,	2	7	6
12 ,, ,, ,, ,,	2	4	0
11 ,, ,, ,, ,,	2	0	6
10 ,, ,, ,, ,,	1	17	0
9 ,, ,, ,, ,,	1	13	6
8 ,, ,, ,, ,,	1	10	0
7 ,, ,, ,, ,,	1	6	6

Platinum.—(Sym., Pt.; At. wt., 98·5).—"A metal of a greyish white colour, harder than silver, and of about double its density, being of specific gravity 21. It is so infusible that no considerable portion of it can be melted by the strongest heats of our furnaces. It is unchangeable in the air and water, nor does a white heat impair its polish. The only acid which dissolves it is the nitro-muriatic (aqua regia).

Great improvements in refining platinum have been introduced by Messrs. Deville & Debray. In a furnace composed of blocks of lime the platinum is fused by means of the oxyhydrogen flame." *

* Ure's "Dictionary of Arts."

Platinum Alloys.—7 parts of platinum and 3 *gold* form an alloy infusible in the strongest blast-furnace. Alloys containing a large proportion of gold fuse at that degree of heat (Prinset). 2 parts platinum and 1 gold form a brittle alloy; 1 part platinum and 1 gold form a very malleable alloy having nearly the same colour as gold. The alloy of 1 part platinum and 9·6 gold has the colour of gold and the density of platinum. 1 part platinum and 11 gold form a greyish white alloy, like tarnished silver.

Silver unites with platinum in all proportions. A very small quantity renders silver hard. Hot oil of vitriol dissolves out the silver from the alloy and leaves the platinum.

With *copper*, platinum does not combine below a white heat.

Lead unites very easily with platinum. 1 part of spongy platinum and 2·7 of lead heated to redness together combine without visible combustion, and form an easily fusible compound which has the colour of bismuth, splits under the hammer, and exhibits a fibrous texture.

Equal parts of platinum and *palladium* unite somewhat below the melting point of the latter, forming a grey alloy as hard as wrought iron, having a specific gravity of 15·141, less ductile than the alloy of palladium and gold.

Palladium.—(Sym., Pd.; At. wt., 53·36).—The specific gravity of palladium is 11·8 to 12·14. It is found in native platinum, also as an alloy with gold, in Brazil, and in many varieties of native gold. It is one of the hardest of the metals;

colour not so bright as that of silver; it is malleable, ductile, and capable of being welded. Palladium is more oxidisable than silver, for it tarnishes in air at the ordinary temperature. When heated in air it becomes blue at first from partial oxidation; but if the temperature be increased, this colour disappears and its brightness returns. It is remarkable that, though silver tarnishes, and palladium does so in a still greater degree, an alloy of the two metals does not tarnish, and such an alloy is on account of this valuable property frequently used by dentists as a base on which to mount the artificial teeth.

The union of palladium with gold injures the colour, and even 1 per cent. may be detected by sight and 5 per cent. renders it a silver colour, while about 10 per cent. destroys it: but the ductility of the alloy is not much injured.

The alloys of silver and palladium may be made in any proportions; it has been found that even 3 per cent. of palladium prevents silver tarnishing so soon as without it, 10 per cent. very considerably protects the silver, and 30 per cent. of palladium will prevent the silver being affected by fumes of sulphuretted hydrogen unless very long exposed. The latter alloy has been found useful for dental purposes, and the alloy with less proportions—say 10 to 15 per cent.—has been used for graduated scales of mathematical instruments.*

Silver.—(Sym., Ag.; At. wt., 10·8).—"When pure and polished, silver is the brightest of the metals. Its specific gravity in the ingot is 10·47; but

* Ure.

when condensed under the hammer or in the coining press it becomes 10·5. It melts at a bright red heat, at a temperature estimated by some as equal to 1,873° Fah. It is exceedingly malleable and ductile, affording leaves not more than $\frac{1}{100000}$ of an inch thick, and wire far finer than a human hair. By Sickington's experiments, its tenacity is to that of gold and platinum, as the numbers 19, 15, and $26\frac{1}{4}$, so that it has an intermediate strength between these two metals. Pure atmospheric air does not affect silver, but that of houses impregnated with sulphuretted hydrogen soon tarnishes it with a film of brown sulphide. It is distinguished chemically from gold and platinum by its ready solubility in nitric acid, and from almost all other metals by its saline solutions affording a curdy precipitate with a most minute quantity of sea-salt or any soluble chloride." *

Silver is used in combination with *palladium* in the proportion of 100 silver to 30 palladium, to form an alloy sometimes used for "base plates." It is also alloyed with *platinum* for the same purpose.

Copper.—(Sym., Cu.; At. wt., 31·7).—One of the metals most anciently known. It was named from the island of Cyprus, where it was most extensively mined and smelted by the Greeks. It has a reddish brown colour inclining to yellow, a faint but nauseous and disagreeable taste, and when rubbed between the fingers imparts a smell somewhat analagous to its taste. Its specific gravity is from 8·8 to 8·9. It is much more malleable than ductile, so that far finer leaves may be obtained from it

* Ure.

than wire. Its melting point is stated to be 1,996° Fah.; at a higher temperature it evaporates in fumes which tinge flame a bluish green. By exposure to heat with access of air, it is rapidly converted into black scales of protoxide. In tenacity it yields to iron, but considerably surpasses gold, silver, and platinum in this respect.

Aluminium.—(Sym., Al.; At. wt., 13·7).—This metal is extremely light, its specific gravity being only 2·56; thus gold is more than seven times, and platinum more than eight times, heavier. Its colour is white, but with a bluish tinge resembling lead, and its fusing point is between the melting points of zinc and silver. It is not acted upon by cold nitric acid, very slightly attacked by dilute sulphuric, but readily dissolved by hydrochloric acid with evolution of hydrogen.

Alloys of Aluminium.—Very small quantities of other metals suffice to destroy the malleability and ductility of aluminium. With 1-20th of iron or copper it cannot be worked, and 1-10th of copper renders it as brittle as glass. Silver and gold produce brittleness in a less degree. An alloy of 5 parts of silver with 100 of aluminium is capable of being worked like the pure metal, but it is harder and therefore susceptible of a finer polish: whilst the alloy containing 10 per cent. of gold is softer, but, nevertheless, not so malleable as the pure metal. The presence of even 1-1,000th part of bismuth renders aluminium brittle in a high degree.

Copper alloyed with only 1-10th of its weight of aluminium has the colour and brilliance of gold, and is still very malleable.

Aluminium may be gilded by being dipped into a solution of the hyposulphate of gold, after it has been well cleaned by the successive use of potash, nitric acid, and water.

It is soldered with difficulty. The most successful method is to coat the aluminium with copper by the electrotype process, after which soldering can be effected in the usual way. Otherwise the soldering should be effected in the following manner. The pieces of aluminium intended to be soldered must be prepared in the same manner as objects are treated for soldering with "tin," viz. by a tinning, but this tinning must be done with the solder itself. The pieces to be soldered thus "tinned" beforehand are afterwards bound together and exposed to the flame of either a glass blowpipe or other source of heat. In order to unite the solderings, small tools of *aluminium* are used. These tools are used as little soldering instruments, and they facilitate at the same time the fusion of the solder and its adhesion to the previously prepared aluminium. Use no flux to make the solder melt. The use of the little tools is an art which the workman must acquire by practice; in fact at the moment of fusion the solderings must have the friction applied as they melt suddenly in a complete manner.

SOLDERS FOR ALUMINIUM.

	1.	2.	3.	4.
Zinc . . .	80	85	88	90
Copper . .	8	6	5	4
Aluminium .	12	9	7	6

No. 1 is most fusible. No. 4 is most preferred, particularly for smaller objects.

In making the solder, the copper is first melted, the necessary aluminium is added and stirred with an iron spatula (unpolished as it comes from the blacksmith). The zinc is then added, avoiding too much heat, as this last metal is easily oxidized and very volatile.

Zinc.—(Sym., Zn.; At. wt., 32·5).—This metal is of a bluish white colour, of considerable lustre when broken, but easily tarnished by the air; its fracture is hackly, and foliated with small facets irregularly set. It has little cohesion, and breaks in thin plates before the hammer unless it has been previously subjected to a process of lamination at the temperature of from 220° to 300° Fah., by which it becomes malleable and ductile.

The specific gravity of zinc varies from 6·9 to 7·2 according to the degree of condensation to which it has been subjected. It melts under a red heat at 773° Fah. When strongly heated with contact of air, the metal takes fire and burns with a brilliant bluish white light. The result of this combustion is the white powder "ozide of zinc."

The malleability of zinc depends in a certain degree upon the temperature at which it has been melted: when cast near the temperature of its melting point, it is more malleable than when cast at a higher temperature.

The discovery that zinc is malleable is comparatively recent, and since that time the rolling of zinc has become a manufacture of considerable importance.*

* Ure.

Reduction of Zinc by Carbon and Carbonic Oxide.—The oxide is reduced by either of these agents at a strong red heat. In order that complete reduction should be effected by carbon, it is not necessary that the oxide of zinc and solid carbonaceous matter should be intimately mixed.*

Lead.—(Sym., Pb.; At. wt., 103·572).—Lead is of a bluish grey tint; its specific gravity is 11·4, and it is the softest metal in common use. Lead is very malleable, and may be rolled into thin sheets, but its ductility is not great, and it cannot be drawn into fine wire.

When a pig of lead is heated to a certain degree bordering on its melting point, and then struck sharply with a hammer, it breaks into pieces having a remarkable columnar structure, like tin similarly treated.

When two plane and perfectly clean surfaces of lead, such as may easily be produced by cutting the metal with a sharp knife, are pressed together, they adhere with great tenacity.†

Mercury.—(Sym., Hg.; At. wt., 100).—"Mercury is often found native in globules disseminated through its ores: it occurs also combined with silver and with gold in the form of amalgams, also as iodide and chloride, and very rarely as selenide; but the most abundant ore is the sulphide, or cinnabar, from which nearly all the mercury of commerce is obtained. Its most important mines are those of Idria, in Illyria, and of Almaden, in Spain. At Almaden it is found in veins, often nearly fifty feet thick, traversing

* Percy's "Metallurgy." † Ibid.

the micaceous schists of the older transition period."

Purification from Foreign Metals.—"A small quantity of mercury may be speedily purified by placing it in a bottle with a little finely powdered loaf-sugar, the mercury not occupying more than one-fourth of the capacity of the bottle; the bottle is then closed and briskly agitated for a few minutes, after which the stopper is withdrawn, and fresh air blown into the bottle with a pair of bellows, and the agitation is repeated; this is done three or four times, and the mercury is then poured into a cone of smooth writing paper, having a pin hole at its apex. The metal then runs through, leaving the pounded sugar mixed with the oxides of the foreign metals, and a considerable quantity of finely divided mercury.

"Pure mercury should leave no residue when dissolved in nitric acid, evaporated and ignited, or when fused with sulphur and sublimed in a glass flask. When made to run down a gently inclined surface it should retain its round form, and *not drag a tail;* and when agitated in a bottle with dry air it should not yield any black powder."*

Properties.—Mercury freezes at 37·9° Fah. undergoing considerable contraction at the moment of congelation, and forming a tin-white, ductile mass, crystallized in octahedrons and needles, capable of being cut with a knife, and exhibiting a granular fracture. When heated to 662° Fah. mercury boils, and forms an invisible transparent

* Watts's "Dictionary of Chemistry."

vapour of specific gravity 6·976. The specific gravity of this metal at 60° Fah. is 13·56.

Silver Solders.

Description.	Fine Silver.	Copper.	Spelter.
Hard solder	16 parts	3½ parts	½ part
Medium solder	15 ,,	4 ,,	1 ,,
Easy common solder	14 ,,	4½ ,,	1½ ,,
Common hard	12½ ,,	6 ,,	1½ ,,
Common easy	11½ ,,	6½ ,,	2 ,,

Fusing Points of Above.

No. 1.	Hard solder	1,866 deg. Fah.
,, 2.	Medium solder	1,843 ,,
,, 3.	Easy solder	1,818 ,,
,, 4.	Common solder	1,826 ,,
,, 5.	Common easy solder	1,802 ,,

Soft Solder.

Pure grain tin	2 parts.
Pure lead	1 part.

Melt in an iron ladle, lead first, then after heating the tin over the ladle add it to the melted lead.

Soft Soldering Fluid.

Spirits of salt	2 parts.
Metallic zinc	1 part.

Procure an earthen pipkin, and put into it 2½ ozs. of spirits of salts and 1 oz. of metallic zinc in small pieces. When the zinc has dissolved, or the effervescence has partially ceased, the temperature may conveniently be increased by placing the pipkin with its contents upon a sheet of iron over a gas-jet; the extra half-ounce of spirits of salts will allow for loss by evaporation. Sometimes it will be found necessary, especially when the acid is not good, to increase its temperature in order to effect its thorough saturation, for the more neutral the mixture the better it acts. The solution may be allowed to settle when sufficiently acted upon, and the supernatant liquor poured from the sediment into a bottle ready for use. This mixture will keep any length of time in a corked bottle. When this is employed in soft-soldering iron or steel, the addition to it of a small portion of powdered sal-ammoniac is a great improvement; a quarter of an ounce to the proportion of solution given above will form a very good mixture.

CHAPTER XVII.

PROPERTIES OF METALS, SPECIFIC GRAVITY, ETC.

Properties of Metals.—*Tenacity.*—The tenacity of the metals has been measured by fixing firmly in a vice one end of a bar or wire of the metal, the strength of which is to be ascertained, and attaching to the other end a convenient support for weights, which are cautiously increased until the wire breaks. Taking the tenacity of lead as 1, that of the different metals after annealing is as follows[a]:—

Lead	1	Silver	8·9
Cadmium	1·2	Platinum	13
Tin	1·3	Palladium	15
Gold	5·6	Copper	17
Zinc	8	Iron	26

Copper, it will be observed, resists being torn asunder with three times the power of gold.

Malleability.—Gold is the most malleable of metals; that is, it can be hammered out into the thinnest leaves—it can be beaten out so thin that one square foot weighs less than 3 grs.

[a] Miller's "Chemistry."

The following gives the order of malleability of the metals beginning with the most malleable :—

1. Gold.
2. Silver.
3. Copper.
4. Platinum.
5. Palladium.
6. Iron.
7. Aluminium.
8. Tin.
9. Zinc.
10. Lead.
11. Cadmium.
12. Nickel.
13. Cobalt.

Ductility.—This property of being drawn into wire is given in the following order, beginning with the most ductile :—

1. Gold.
2. Silver.
3. Platinum.
4. Iron.
5. Copper.
6. Palladium.
7. Cadmium.
8. Cobalt.
9. Nickel.
10. Aluminium.
11. Zinc.
12. Tin.
13. Lead.
14. Thallium.
15. Magnesium.
16. Lithium.

Expansion of Metals.

Zinc (cast)	1 in 323
Zinc (sheet)	1 in 340
Lead	1 in 351
Tin	1 in 516
Silver	1 in 524
Copper	1 in 581
Brass	1 in 584
Pure gold	1 in 682
Iron wire	1 in 1802
Palladium	1 in 1000
Platinum	1 in 1167

Expansion of Liquids.

Spirits of wine expand	$\frac{1}{9}$,	that is,	9	measures become	10
Fixed oils	,, $\frac{1}{12}$,	,,	12	,, ,,	13
Water	,, $\frac{1}{22.76}$,	,,	22·76	,, ,,	23·76
Mercury	,, $\frac{1}{55.5}$,	,,	55·5	,, ,,	56·5

Spirits of wine is therefore six times more expansible by heat than mercury is. The difference in the heat of the seasons affects sensibly the bulk of spirits. In the height of summer spirits will measure 5 per cent. more than in the depth of winter.

Specific Gravity.—The specific gravity of a body is its weight as compared with an equal bulk of another body which is taken as the standard. For solid bodies and liquids the standard of reference is pure water at a temperature of 60° Fah.; water is stated as 1 (or 1000), so that gold, whose specific gravity is stated at 19·5, is thus exactly 19½ times heavier than water, bulk for bulk. For gases the common standard is air, but frequently hydrogen is taken as the standard by the chemist.

Method of obtaining the Specific Gravity of Solids by the Hydrostatic Balance.—Any ordinary balance which acts accurately may be used for this operation, one pan being made shorter than the other.

When the substance is *solid, heavier than water, and insoluble in it*, it is first weighed in the usual manner, then it is suspended by means of a horse-hair attached to the lower surface of the short pan of the balance; a vessel of distilled water is so placed that the substance will hang freely in it, so as not to touch the side, and the surface of the substance should be free from air bubbles. The loss of weight sustained by the substance when thus immersed is exactly equal to its own volume of water which it has displaced. It is then necessary to place weights in the short pan until the equilibrium is restored. To calculate the specific gravity, we have

only to divide the weight in air by the loss of weight in water. Where the substance is solid, and insoluble in but *lighter* than water, it must be attached to a piece of lead (or other substance sufficiently heavy to sink it); the two are then weighed in the water as before.

To ascertain the specific gravity in such cases, the lead must be weighed first by itself in water, and then with the lighter substance attached to it in water also; subtract the latter weight from the former and to the result add the weight of the light substance in air, then divide the last weight (that of the light substance in air) by the number so obtained; the result is the specific gravity of the light substance.

Or, to state the problem in algebraic formula, only three data are required, viz.: the weight in air of the light substance = P; the weight in water of the piece of lead (or other heavy substance) = P′; and the weight in water of the light substance and the lead attached to each other = P″. We have then the density D by the following expression:—

$$D = \frac{P}{P' - P'' + P}$$

SPECIFIC GRAVITY OF VARIOUS QUALITIES OF GOLD, &C.

Carat.	Spec. Grav.
24	19·5
23	19·08
22	18·68
20	17·87

Carat.	Spec. Grav.
18	17·05
15	15·74
13	14·86
12	14·45
10	13·6
9	13·2
8	12·82
7	12·5
Silver, pure	10·5
Copper, pure	8·96
Composition	8·37
Spelter	7·2

By the above table, the quality of any gold plate or article may very closely be ascertained, if the gold be first weighed, and its specific gravity ascertained by means of the hydrostatic balance as described. For example, suppose we wish to know the carat value of a "strange" plate, we weigh it in water and find that its specific gravity is, say, 14·5; comparing this with the numbers in the table, we find that the plate is a fraction above 12 carat.

Specific Gravity of the Metals.

	Spec. Grav.
Platinum	21·53
Gold	19·5
Mercury	13·596
Palladium	11·8
Lead	11·36
Silver	10·53
Bismuth	9·799
Copper	8·95
Nickel	8·82
Cadmium	8·694

	Spec. Grav.
Manganese	8·013
Iron	7·844
Tin	7·292
Zinc	7·146
Antimony	6·71
Aluminium	2·67

FUSING POINTS OF GOLD AND OTHER METALS.

[The following Table is given by Gee.]

	Deg. Fah.
23 carat gold melts at	2012
22 ,, ,,	2009
20 ,, ,,	2002
18 ,, ,,	1995
15 ,, ,,	1992
13 ,, ,,	1990
12 ,, ,,	1987
10 ,, ,,	1982
9 ,, ,,	1979
8 ,, ,,	1973
7 ,, ,,	1587

			Deg. Fah.
Mercury	melts	at	37·9
Tin	,,	,,	442
Cadmium	,,	,,	442
Bismuth	,,	,,	507
Lead	,,	,,	617
Zinc	,,	,,	773
Antimony	,,	,,	1150
Silver	,,	,,	1873
Copper	,,	,,	1996
Gold	,,	,,	2016
Cast iron	,,	,,	2786
Palladium, Platinum	require the heat of the oxyhydrogen blowpipe.		

Thus it will be seen that while mercury remains

fluid at a temperature as low as 37·9° below the zero of Fahrenheit's scale, tin, cadmium, bismuth, lead, and zinc melt below redness;* antimony above a red heat; silver, copper, and gold require a bright cherry-red heat; iron requires a white heat; and platinum and palladium require to effect their fusion the intenser heat of the oxy-hydrogen blowpipe. Some metals near their melting points, before undergoing complete fusion, pass through a soft intermediate stage, in which, if two clean surfaces be presented to each other, and strong pressure or hammering be employed, they unite or weld together so as to form one continuous mass. Iron, thallium, lithium, and potassium afford the most striking instances of this. Palladium and platinum are also susceptible of it.

* Vide pp. 254, 255.

CHAPTER XVIII.

*ELECTRO-GILDING.**

FOR the purpose of giving to gold plates that uniformity of colour which is wanting where a considerable surface of solder exists—as is the case with flat teeth—some dentists give them a coating of fine gold by means of the "battery process."

The apparatus and materials required are a battery, a thin plate of fine gold, and a pot containing a solution of fine gold with cyanide of potassium; two copper wires proceed from the battery, the one joined to the zinc and the other to the platinum, and reach over to the vessel containing the solution, and to these extremities, which are bent to a hook shape, the fine gold and the plate to be coloured are attached. The *fine gold* is invariably attached to the wire which proceeds from the *platinum of the battery*—the positive pole; the *plate to be coloured* is invariably attached to the wire which proceeds from the *zinc*—the negative pole. The solution is heated to 150 Fah. before com-

* As many dentists adopt this practice with a *legitimate* object, we have inserted this chapter on the subject in the hope that it will enable them to obtain satisfactory results.

mencing this operation, and the gold plate, which must be carefully cleaned, should remain in a basin of pure water until all is prepared for dipping. It is then suspended upon its proper wire, and, along with the fine gold which is upon the other, immersed in the solution. Action at once commences; the effective current of electricity flowing from the zinc to the platinum, thence through the copper wire to the fine gold, and through the solution to the suspended plate upon which it deposits a layer of gold, and so passing onwards by the wire attached to the latter plate it reaches again the zinc, from which it started.

Battery.—The "Smee" battery is most convenient, and is generally employed for this purpose. A single cell arrangement (Fig. 101) consists of a sheet of platinized silver placed between, but without touching two plates of amalgamated zinc. So as to keep the zinc plates apart, a slip of varnished wood is interposed between them at their upper borders; in a groove on the under surface of this slip, or frame of wood, is secured the silver plate; all the parts are bound together by a brass binding-screw, the silver plate is prevented from touching the amalgamated zincs by pieces of cork placed between them at their lower ends.

This arrangement is then placed in a jar—glass, stoneware, or gutta-percha—containing dilute sulphuric acid (one of acid to ten of water, by measure). It is important that the sulphuric acid (oil of vitriol) should be free from nitric acid (which it sometimes contains), because that acid wastes the zinc, and in Smee's battery also corrodes the silver.

The gilding operation may be performed with the one cell. In that case the gold solution must be heated to a higher degree (200 Fah.) than when the double cell is used. The latter is commonly employed.

The battery may easily be constructed in the workroom. The following particulars will be found of service whether they be so made or whether they be purchased, as in the latter case it is still necessary to amalgamate the zincs from time to time; further, the success of the operation depends upon maintaining the apparatus and solution in good working order, and to accomplish this some acquaintance with details is necessary.

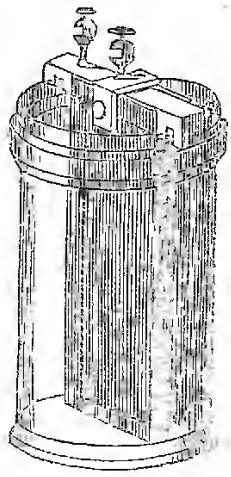


Fig. 101. Smee's Battery.

First, with regard to the platinized silver plate, which constitutes the negative *metal* (the copper wire attached to this and reaching to the solution is called the positive *pole*). The silver to be prepared for this should be of a thickness sufficient to carry the current of electricity (about the thickness of pattern lead), and should be roughened by brushing it over with a little strong nitric acid, so that a frosted appearance is obtained. It is then washed and placed in a vessel with dilute sulphuric acid, to which a few drops of nitro-muriate of platinum has been added; a porous tube is then placed into this vessel with a little dilute sulphuric acid. Into this tube a piece of zinc is put, contact being made between the zinc and silver; the

platinum will in a few seconds be drawn down upon the silver as a black metallic powder. The operation is now completed and the platinized silver ready for use. A simple method which obviates the use of a battery may be adopted. Place the silver between two pieces of sandpaper, and press it with a common smoothing-iron, then pull the silver out while under the pressure. The platinum solution is made very hot, and the silver dipped into it for some time, which effects the coating. The nitro-muriate of platinum is easily prepared.' Take one part of nitric acid and two parts of hydrochloric, mix together, and add a little platinum, either as metal or sponge; keep the whole at or near boiling point; the metal is then dissolved, forming the solution required.

The zinc plates used are from 4 to 6 inches long by 4 broad, and they should be at least $\frac{1}{8}$ of an inch thick. The following is from Napier's "Electro-Metallurgy."

Zinc for Battery.—The zinc used for the battery should be *milled* or rolled zinc, not thinner than $\frac{1}{8}$ of an inch, otherwise the waste will be very great. The best thickness when their size is upwards of 4 inches square is $\frac{1}{4}$ of an inch.

Amalgamation of the Zinc Plates.—A mixture of eight parts water and one sulphuric acid is put into a stoneware basin, which should be large enough to allow the zinc plate to lie flat in it; the acid should cover the zinc plate, which must remain until the surface becomes perfectly bright. The pan is now raised on one side, and a little mercury put into the lower part, care being taken that the

zinc does not touch the mercury, to prevent which is the object of raising the pan on one side. A little coarse tow, tied to the end of a piece of wood, is dipped into the mercury, which lifts small portions of the metal mechanically, which is then rubbed with considerable pressure upon both sides of the zinc plate, over which the mercury flows easily; the plate is then washed by dipping it into clear water, and is next made to stand upon its edge in another pan with two small pieces of wood under it, so as to allow any excess of mercury to drain from it. After the zincs have drained for a few hours the process should be repeated, only it is not necessary to allow the metal to lie in the acid in the second process previous to rubbing in the mercury; after draining a few hours the second time amalgamation is completed. The zinc plates should always be removed from the battery immediately after the gilding operation is completed, and the surface carefully brushed with a *hard* hair-brush in water, and then laid by in a safe place.

If the battery is to be used seldom, and only for a short period at a time, or if the zinc is thin, another method of amalgamation may be adopted. The zinc plate, after lying in the dilute acid till the surface is bright, may be rubbed over with a solution of nitrate of mercury, which gives a very thin amalgamation; but this method is unsuitable if the battery is to be used for several hours together.

Battery Process of preparing the Gold Solution.—This is the best and cheapest method of

making up the solution; it saves all expense of acids and the labour of precipitation and washing necessary in preparing it from the chloride of gold. Say the operator wishes to prepare a gallon of gold solution, he dissolves 4 ounces of cyanide of potassium in 1 gallon of water, and heats the solution to 150 Fah.; he now takes a small porous cell and fills it with this cyanide solution, and places it inside the gallon of solution. The two solutions should be on a level. Into this cell is put a small plate of iron or copper, and attached by a wire to the zinc of a battery. A piece of gold is placed into the large solution, facing the plate in the porous cell, and attached to the copper of the battery; the whole is allowed to remain in action until the gold, which is to be taken out from time to time and weighed, has lost the quantity required in solution. The solution in the porous cell, except the action has continued a long time, will have no gold, and may be thrown away. Half an hour will suffice for a small quantity of solution. For all the operations of gilding by the cyanide solution, it must be heated to at least 130 Fah. Any convenient means may be adopted for heating the solution. Where glass or stoneware vessels are used for holding the gilding solution, these are placed in another vessel, made of tin plate or iron, of the same depth, and filled to within an inch of the mouth with water, and placed upon a hot plate over a fire, or over gas burners, and the water heated to the boiling point.

If two pairs of plates be used, the solution should be kept at about 150° Fah. while gilding; if only

one pair, the heat of the gold solution should be raised to 200° Fah.

Conditions required in Gilding.—The gilding solution generally contains one-half to an ounce of gold in the gallon; but for colouring small articles a weaker solution will do. The solution should be sufficient in quantity to entirely cover the article at once, so that it should not have to be done bit by bit. The rapidity with which metals are acted upon at the surface line of the solution is remarkable. If the positive electrode is not wholly immersed in the solution, it will in a short time be cut through at the surface of the water as if cut by a knife.

Maintaining the Gold Solution.—As the gold solution evaporates by being kept hot, distilled water must from time to time be added. This water should always be added when the operation of gilding is over for the time, not when it is about to be commenced, or the solution will not give so satisfactory a result. The average cost of depositing gold is about 2d. per dwt.

To obtain a deposit of a good colour, much depends upon the heat and state of the solution and battery. It is therefore necessary that strict attention be paid to these, and also the weight of gold deposited, and the loss sustained by the positive electrode. The plate of pure gold which is attached to the wire proceeding from the platinum of the battery should, in regard to its surface, be as near as possible equal in extent to the article to be coloured.

From time to time a little cyanide of potassium must be added to the gold solution; if the gold

pole has a film or crust upon it when withdrawn from the solution, that is a certain indication that the latter is deficient of cyanide of potassium; if the gold pole comes out clean the solution is right. Care must be taken to distinguish the crust, which is occasionally dark green or black, from a black appearance which the gold pole will take when it is very small in comparison with the article being gilt, and which is caused by the tendency to evolve gas. In this case an addition of cyanide of potassium would increase the evil. The black appearance, from the tendency to the escape of gas, has a slimy feel and look. This generally takes place when the solution is nearly exhausted of gold, of which fact this appearance, taken conjointly with the relative sizes of the electrodes, is a sure guide.

To regulate the Colour of the Gilding.—The gold upon the gilt article, on coming out of the solution, should be of a dark yellow colour, approaching to brown; this when "scratch-brushed" will yield a beautifully rich deep gold. If the colour is blackish it ought not to be finished, for it will never either brush or burnish a good colour. If the battery is too strong, and gas is given off from the article, the colour will be black; if the solution is too cold, or the battery rather weak, the gold will be light coloured. A very rich dead shade may be made by adding ammoniuret of gold to the solution just as the articles are being put in. If a bright clear yellow gilding is wanted, that will require no scratch-brushing, add to the solution a small quantity of caustic soda.

Preparation of Articles for Plating.—Articles

that are to be plated are first boiled in an alkaline ley to free them from grease, then washed from the ley and dipped into dilute nitric acid, which removes any oxide that may be formed upon the surface; they are afterwards brushed over with a hard brush and sand, of which a kind obtained from the Isle of Wight, and known as silver sand, is the best. The alkaline ley should be in a caustic state, which is easily effected by boiling the carbonated alkali and adding slaked lime, until, on the addition of a little acid to a small drop of the solution diluted with cold water, no effervescence occurs. The lime is then allowed to settle, and the clear liquid is fit for use. The ley should have about half a pound of soda-ash or pearl-ash to the gallon of water. The nitric acid, into which the article is dipped, may be diluted to such an extent that it will merely act upon the metal. Any old waste acid used for dipping before plating will do for this purpose. The article, being thoroughly cleaned and dried, is weighed, and a copper wire attached to it, either by twisting it round the article or putting it through any open part of it to maintain it in suspension. It is then dipped into strong nitric acid as quickly as possible, washed through water, and then immersed in the gold solution, suspending it from the wire connected with the zinc of the battery. This first immersion should only be continued long enough to impart a blush of gold; the article is then taken out and again brushed and put back into the solution, and kept there for three or four minutes, which will be sufficient if the solution and battery

are in good condition; but the length of time necessarily depends on these two conditions, which must be studied and regulated by the operator.

When taken from the solution the article, if it is not wanted to have a *dead* surface, is brushed with a hard hair-brush and old ale, beer, or water containing in solution a little gum, glue, or sugar.

Roseleur says, "I do not hesitate to state that, even with very inferior electro-plating solution, good results may be arrived at if the *cleansing* is perfect, while the converse cannot be maintained."

Such is the method employed where electro-plating is carried on upon a large scale, and it shows how important it is to have the articles in a perfect state of cleanliness before immersing them in the solution in order to obtain good results. Dentists seldom put the work through all these preparations, however, and simply wash the plate thoroughly after polishing at the wheel, and leave it in a basin of pure water until ready to immerse it in the solution.

Glass hooks should be used for manipulating with. They are very easily made by heating and bending a glass rod over the bunsen flame into a convenient shape, one end being turned back upon itself to form the handle, and the other bent to a hook shape. These are used if the plate should happen to fall into the solution.

CHAPTER XIX.

MISCELLANEA.

THERMOMETERS, TEMPERING, ETC.

THE scale according to Fahrenheit is the one generally adopted in England for registering degrees of temperature; but the Centigrade thermometer is preferred by scientists. The scales of Reamur and De Lisle are not so generally used as the two former.

The boiling point of water is represented on the Fahrenheit scale as 212°; on the Centigrade as 100°; and on the Reamur as 80°. To change Fahrenheit to Centigrade, subtract 32 from the Fahrenheit degrees, multiply the answer by 5, and divide the product by 9; the result gives the degrees Centigrade. For example, convert 212° Fahrenheit into Centigrade: 32 from 212 gives 180, this multiplied by 5 gives 900, which divided by 9 becomes 100 = the degrees Centigrade, corresponding to 212° Fahrenheit.

To convert Centigrade to Fahrenheit, multiply the degrees Centigrade by 9, divide the product by 5, and add 32 to the quotient; the result gives the degrees Fahrenheit.

The method of converting the degrees of one scale into others is thus stated:—

To convert Fah. to Cent. $\frac{5}{9}$ (F.° − 32) = C.°
" " Cent. to Fah. $\frac{9}{5}$ C.° + 32 = F.°
" " Reamur to Fah. $\frac{9}{4}$ R.° + 32 = F.°
" " Fah. to Reamur $\frac{4}{9}$ (F.° − 32) = R.°

The following table represents the corresponding temperature of Fahrenheit and Centigrade below boiling point.

TABLE OF CORRESPONDING TEMPERATURES ON THE SCALES OF FAHRENHEIT AND CENTIGRADE THERMOMETERS.

Deg. Cent.	Deg. Fah.	Deg. Cent.	Deg. Fah.	Deg. Cent.	Deg. Fah.
100	212	66	150·8	32	89·6
99	210·2	65	149	31	87·8
98	208·4	64	147·2	30	86
97	206·6	63	145·4	29	84·2
96	204·8	62	143·6	28	82·4
95	203	61	141·8	27	80·6
94	201·2	60	140	26	78·8
93	199·4	59	138 2	25	77
92	197·6	58	136·4	24	75·2
91	195·8	57	134·6	23	73·4
90	194	56	132·8	22	71·6
89	192·2	55	131	21	69·8
88	190·4	54	129·2	20	68
87	188·6	53	127·4	19	66·2
86	186·8	52	125·6	18	64·4
85	185	51	123·8	17	62·6
84	183·2	50	122	16	60·8
83	181·4	49	120·2	15	59
82	179·6	48	118·4	14	57·2
81	177·8	47	116·6	13	55·4
80	176	46	114·8	12	53·6
79	174·2	45	113	11	51·8
78	172·4	44	111·2	10	50
77	170·6	43	109·4	9	48·2
76	168·8	42	107·6	8	46·4
75	167	41	105·8	7	44 6
74	165 2	40	104	6	42·8
73	163·4	39	102·2	5	41
72	161·6	38	100·4	4	39·2
71	159·8	37	98·6	3	37·4
70	158	36	96·8	2	35 6
69	156·2	35	95	1	33·8
68	154·4	34	93·2	0	32
67	152·6	33	91·4		

The Tempering of Instruments and Tools.—As many are in the habit of reshaping and tempering their own excavators, &c., and all may occasionally find it necessary to adapt an instrument for special circumstances, the following remarks upon tempering may be of value.

Before the instrument can be filed or bent into shape, its temper must be taken out; this is done by heating it to a red heat. But it must be remembered that *over-heating* destroys the steel and permanently deprives it of its essential qualities. An instrument heated to a white heat, for example, cannot subsequently be satisfactorily tempered, and may indeed be considered altogether useless. Therefore it is most important to remember that in heating to extract the "temper" of the instrument or tool that is to be reshaped, only a dull red should be given to the metal; it is then allowed to cool in air, when it may be worked upon. After being shaped, fine filed, and smoothed, the instrument is next heated in the flame to a cherry red, and instantly plunged into cold water. This operation leaves the steel too hard for our purpose, so that it is necessary to "draw" the temper to the required amount. This is done by very carefully heating the instrument more or less according to the work it is designed for. The *point* is first brightened by rubbing it on sand-paper, so that the colours which the heat imparts to the steel may be clearly observed. A pale straw colour is the one allowed for excavators; when that is reached the instrument is at once withdrawn from the flame. Or the following method may be adopted.

"For excavating instruments cover with oil and hold over the alcohol lamp, apply the heat to the instrument a little back from the point, and move it backwards and forwards in the flame so as to heat it up slowly and uniformly, and at the instant the oil takes fire at the point of the instrument it should be plunged into cold water."

Tempering Liquid.—2 quarts soft rain water, ½ oz. corrosive sublimate, 1 oz. common salt.

Tempering Drills and Gravers.—When the graver or drill is too hard—which may be known by the frequent breaking of the point—temper as follows: heat a poker red hot and hold the graver to it within an inch of the point, waving it to and fro till the steel changes to a light straw colour; then put the point into oil to cool.

Steel alloyed with 1-500th part of platinum is rendered harder, more malleable, and better adapted for cutting instruments.

Pouillet has employed an air thermometer provided with a bulb of platinum to determine with precision high degrees of temperature.*

Results.

	Fah. Deg.	Cent. Deg.
Incipient red heat corresponds to	977	525
Dull " "	1292	700
Incipient cherry red "	1472	800
Cherry red "	1652	900
Clear cherry red "	1832	1000

* Percy's "Metallurgy."

	Fah. Deg.	Cent. Deg.
Deep orange corresponds to	2012	1100
Clear ,, ,,	2192	1200
White ,,	2372	1300
Bright white ,,	2552	1400
Dazzling ,,	2732 to 2912	1500 to 1600

TABLE FOR TEMPERING.

		Fah. Deg.	
1.	Very pale straw yellow	438	Tools for metal
2.	Shade of darker ,,	450	excavators, &c.
3.	Darker straw	470	Tools for wood,
4.	Still darker straw	490	screw taps, &c.
5.	Brown	500	Hatchets, chipping,
6.	Yellow tinged slightly with purple	520	and other percussion
7.	Light purple	530	tools, saws, &c.
8.	Dark ,,	550	
9.	Dark blue	570	Springs.
10.	Paler ,,	590	
11.	Still paler blue	610	Too soft for above
12.	,, ,, tinge of green	630	purposes.

TABLE OF USEFUL NUMERICAL DATA.

1 centimetre	=	·3937 inches.
1 decimetre	=	3·937 ,,
1 metre	=	39·37 ,,
1 gramme	=	15·432 grains.
1 kilogramme	=	15432 ,,
1 ,,	=	35·274 ounces, avoirdupois.
1 ,,	=	2·2046 pounds ,,
1 ounce avoirdupois	=	437·5 grains.
1 pound ,,	=	7000 ,,

"Electro-Metallurgy" (Gore).

1 pennyweight troy	=	24 grains.
1 ounce ,,	=	480 ,,
1 pound ,,	=	5760 ,,
1 litre of water	=	15432 ,,
1 ,,	=	1000 grammes.
1 ,,	=	35 ounces by measure.
1 gallon of water	=	4·536 litres.
1 ,,	=	70000 grains.
1 cubic inch of water	=	252·5 ,,
1 ounce measure	=	1·733 cubic inches.
1 pint (or 20 ounces)	=	34·659 ,,
1 gallon (or 160 ounces)	=	277·276 ,,
1 litre	=	61·024 ,,

At the ordinary temperature and pressure of the atmosphere 100 cubic inches of—

		grs.			grs.
Hydrogen	weigh	2·11	Oxygen	weigh	33·80
Ammonia	,,	18·00	Carbonic anhydride	,,	46·50
Hydrocyanic acid	,,		Sulphurous ,,	,,	67·78
Vapour	,,	28·57	Chlorine	,,	76·40
Nitrogen	,,	29·70	Sulphuretted hydrogen	,,	80·50
Atmospheric air	,,	31·00			

Soldering on Casting Sand instead of Plaster.—"A handful of light moist sand, just in a state to cast with, is deposited in the hollow of the casting coke. The two pieces of gold to be soldered together are placed upon it, having been previously stuck together in their relative position, as previously spoken of. They are gently pressed into the sand so as to be supported underneath, everywhere steadily, care being taken not to disturb their relative positions. The sand is pressed down around them so as not to be blowing loosely about when the blowpipe is used, and none is allowed to

remain on the upper surface. The flame is now at once applied with the blowpipe until all the cement has disappeared. With a very light hand place a piece of No. 1 solder on the most convenient part of the joint, but put no borax. This must now be run with the blowpipe so as to hitch the two together. If borax were used it would shift the pieces in rising when heated, sand not being strong enough to resist it. This is the point in soldering in sand which requires more care than soldering in plaster. It is soon learned, and the advantage in time and cleanliness only needs trial to be appreciated. After hitching one point with solder, borax may be freely applied, and the soldering completed. This method can be used in almost all cases where two pieces of gold have to be joined in exact relative positions, such as mounting clasps, &c.; but not in putting up flatbacks, as it is not convenient for the gradual heating they require."—(Mr. Balkwill, *B. J. D. S.*, May, 1876.)

Where this plan is adopted, only new sand, which has not yet been used for casting, should be employed; the sand in use contains particles of zinc and lead, which when heated with it will destroy the gold plate.

Packing the Vulcanite Regulating Pieces without using Wax Plates.—This plan, suggested by Mr. Caleb Williams, is further referred to by Mr. Balkwill in the *British Journal of Dental Science* for January, 1876. He says, "The plaster model is not dipped in wax but dried, and, whilst warm, coated by a camel's-hair pencil with a chloroform solution of uncooked rubber. I generally use the

'whalebone.' This coat is laid on while the model is warm to promote the evaporation of the chloroform, which makes the rubber spongy if any remains. The solution should be carried wherever the plate is intended to go.

"A pattern in sheet lead having been previously prepared, a plate is cut by it out of the soft rubber, which is placed upon the model and carefully pressed with the forefinger into all the inequalities of the impression. The rubber will be found to adhere to the previous coating with the greatest tenacity, therefore a little care is necessary in placing in position, as after touching the model it cannot be shifted. This can be done by doubling the pattern over the right forefinger and placing this on the middle of the palate; the two wings can then be brought down and gently pressed into place. Any part that requires strengthening or thickening to carry plugs, &c., must have rubber added, just as in the ordinary method wax is built upon a wax core. The piece is now smothered in plaster, placed in a flask, filled up, and, when the plaster is set, vulcanized. The process up to the vulcanizing occupies from five to ten minutes instead of one or two hours. There is no straining of the model in any way, the fit is exact, and slender teeth and undercuts, which, to say the least, make a difficulty ordinarily, are thus fitted with ease."

Acids, &c., used in the Workroom.—In the text-book of "Electro-Metallurgy," by Gore, the following remarks are made with regard to acids.

Nitric Acid.—Called also aqua-fortis. The pure

acid for dissolving silver, &c., should be colourless, have a specific gravity of not less than 1·52, and separate portions of it, diluted with pure distilled water, should give no cloud with a single drop of solution of nitrate of silver or of chloride of barium. It should be kept in a stoppered bottle, in a dark, cool, and dry place. If a drop of this or any other acid falls upon one's clothes, *diluted* aqueous ammonia should at once be freely applied.

All the pure strong acids should be kept in stoppered bottles in a dry place. Carboys of common acids and dripping liquids should have stoneware stoppers, and be kept in an outhouse.

Hydrofluoric Acid.—Called also fluoric acid. This liquid is always very impure. It should be kept in a bottle of gutta-percha, provided with a stopper of india-rubber, in a dry and cool place, and not in close proximity to glass vessels, because the vapour corrodes them. It is highly dangerous to breathe the fumes of this acid; and if a drop of it falls upon the skin it should be *thoroughly* washed off *at once*, otherwise after a few hours great pain will be suffered.

Hydrochloric Acid.—Called also "muriatic acid," "spirits of salt," and "smoking salts." The pure acid should be colourless, of not less specific gravity than 1·20. It should be kept in a cool place.

Aqua Regia.—Called also nitro-hydrochloric acid. This is a mixture of one volume of nitric and from two to three of hydrochloric acid. It should not be prepared until required to be used, because it decomposes spontaneously.

Sulphuric Acid.—Or "Oil of Vitriol." The pure acid should have a specific gravity of not less than 1·85, and be nearly or quite colourless. The least trace of dust or organic matter imparts a darkness of appearance to it. It should be kept in a dry place. When diluting it, the water should not be poured into the acid, because that is dangerous, but the acid into the water, and that slowly.

Bisulphide of Carbon.—Called also "sulphuret of carbon" and "carbon disulphide." This is a very volatile and inflammable liquid, and a flame should not therefore be brought near its vapour. It should be kept in a well-stoppered or corked bottle in a cool place.

Phosphorus.—This substance should be kept in a wide-mouthed stoppered bottle, filled with water, to keep the air from contact with it. The bottle should also be covered with black varnish, and kept in a dark place, because the light changes the phosphorus and makes it insoluble. Phosphorus should never be exposed to the air for more than a few seconds, or it may inflame; and it should always be cut whilst under the surface of water.

Phosphorus Solution.—Called also "Greek fire." This highly inflammable and dangerous mixture is composed of phosphorus dissolved in bisulphide of carbon. It should only be prepared in small quantity; and the bottle containing it should be kept in a cool place, partly immersed in sand, in a stone-ware vessel covered with a metal lid. It is extremely liable to spontaneous combustion, especially if any be spilt.

Aqueous Ammonia.—Called also "volatile alkali,"

"spirit of hartshorn," &c. This liquid is very volatile, and should be kept in well-stoppered bottles in a very cool place. Its specific gravity should not be greater than ·880. It is dangerous to break the bottles.

Carbonate of Ammonia.—Called also "smelling salts" and "sal volatile." The unchanged substance is in the form of *transparent* colourless pieces. By exposure to air it loses ammonia, and becomes opaque white. It should therefore be kept in well-closed bottles.

Hydrocyanic Acid.—Called also "prussic acid." This is a colourless liquid consisting of water more or less impregnated with the gas. Water will dissolve a very large amount of the gas. The strongest usually sold is known as Scheele's, and contains about 5 per cent. of the actual substance; the ordinary medicinal acid contains only 2 per cent. It is extremely poisonous, and dangerous to smell or inhale the vapour arising from it. It is decomposed by light, and should therefore be kept in an opaque bottle, in a dark and cool place.

Cyanide of Potassium.—Called also "prussiate of potash." This substance also is a deadly poison and almost as dangerous when absorbed by the skin as when swallowed. It is strongly alkaline and abstracts moisture rapidly, and should therefore be kept in well-covered jars or bottles.

Filters.—Small ones for filtering dilute acids or alkalies, and liquids generally, are made by doubling a circular sheet of filtering paper (*i.e.* unsized or blotting-paper) twice at right angles, opening one of the outer folds, and placing the filter in a

glass funnel. Large ones are usually formed by tying or nailing the edges of a piece of washed or unglazed calico to those of a square frame of wood or of a wooden hoop. A filter for strong acids or alkalies is made by placing a loose plug of asbestos in the neck of a glass funnel, or by filling the neck of the vessel with broken glass, and covering the latter with a layer of asbestos.

Remedies for Accidents.—The following, which is also quoted from Gore's work, may be found useful in the workroom.

"As various poisonous substances are employed in the art, it would be well for the operator to know their best antidotes. If either nitric, hydrochloric, or sulphuric acid have been swallowed, the best remedies are either to administer abundance of tepid water to act as an emetic, or to cause the patient to swallow milk, the whites of eggs, some calcined magnesia, or a mixture of chalk and water. If those acids in a concentrated state have been spilled upon the skin, the parts should be washed with plenty of cold water, and if necessary a mixture of whiting and olive-oil then applied. A useful mixture for such cases is formed by slaking about an ounce of caustic lime with a quarter of an ounce of water, then adding it to a quart of water and shaking the mixture repeatedly; decanting the clear liquid, and beating it up with olive-oil to form a thin pomatum. Acids spilled upon the clothes should at once be treated with plenty of a quite dilute solution of ammonia or its carbonate, and then well washed with water.

"In cases where hydrocyanic acid, cyanide of potassium, or the ordinary silvering or gilding solutions have been swallowed, almost instant death usually follows; if it does not, *very cold* water should be allowed to run upon the head and spine of the sufferer, and the patient be made to swallow a dilute solution of either acetate, citrate, or tartrate of iron. If the poisoning arises from inhaling the vapour of hydrocyanic acid, cold water should be applied as above, and the patient be caused to inhale atmospheric air containing a *little* chlorine gas. It is a dangerous practice to dip the naked hands or arms in cyanide solutions, as workmen sometimes do, in order to recover articles which have fallen into them, because those liquids are absorbed by the skin, and produce poisonous effects; they also cause very painful sores, which should be well washed with water, and the mixture of lime-water and olive-oil applied. If alkalies such as potash or soda have been swallowed, a dilute solution of vinegar, some lemonade, or extremely dilute sulphuric acid, should be given, and, after about ten minutes, a few spoonfuls of olive-oil.

"If metallic salts have been taken, the patient should be made to vomit by means of tepid water, and, then to swallow some milk, whites of eggs, precipitated sulphur, or some sulphuretted hydrogen water. To remove stains of sulphate of copper, or of salts of mercury, silver, or gold from the hands, &c., wash them first with a dilute solution either of ammonia, iodide, bromide, or cyanide of potassium, and then with plenty of water; if the stains are old ones, they should first be rubbed

with the strongest acetic acid, and then treated as above.

"Grease, oil, pitch, or tar may usually be removed from the hands, clothes, &c., by rubbing with a rag saturated with benzine, spirits of turpentine, or bisulphide of carbon."

INDEX.

ACIDS used in workroom, 258
Alloying gold, 32
Alloys of gold, 217
platinum, 224
palladium, 225
silver, with platinum and palladium, 226
aluminium, 227
Aluminium, 227
Amalgamation of zinc plates, 244
Annealing gold plate, 53
Anvil, or striking block, 54
Aqua Regia, 259
Articulating frames, 77
teeth, 102
Artificial palates, 186
Asbestos, used with plaster as investient, 85, 155
Austen, Prof., on vulcanizing, 118, 123
table for ascertaining amount of alloy, 213
table of fusible metals, 29

BACKING flat teeth, 83
Balkwill, Mr., soldering on casting sand, 256
Bell and Turner vulcanite flask, 104
Binding wire, used in soldering flat teeth, 85
Bites, obtaining, in wax and plaster, 74
Blowpipe, bellows, 44
hydrostatic, 44—46
mouth, 46
Borax, as flux in gold melting, 37
soldering solution, 49

CASTING plaster models, 13
in sand, 18
rings, 19
sand used to solder upon, 256
Celluloid, 167
Celluloid Machines, 172, 174
Chambers for gold plates, 57
vulcanite cases, 103
Chasing gold plates, 60
Clamps (wire) used in soldering, 58
Clasps for gold plates, 61
vulcanite cases, 116
Coin gold, English, 33
Combination work, 129
Composition, impression, 7, 12, 15
Congenital fissures, 190
Continuous-gum work, 150
Copper frames, for soldering flat teeth, 88
Crucibles, 32
Cutting pliers, 93
Cyanide of potassium, 261

DIES and counters, 26, 55
Die, to prevent splitting of, 55
with plaid teeth, 58
Difficulties in sand casting, 21
Draw-plate, 42
Drawing-tongs, 42
Dressing plaster models, 16
Drying ,, ,, 16

EDENTULOUS cases, trays for, 2
Electro-plating, 241
Evans, Dr., method of retaining upper cases by means of ridges, 127
Expansion of liquids, 235
metals, 235

FAHRENHEIT scale, to convert to centigrade, 251
Fauchard's obturator, 178
Filters, 261
Finishing gold plates, 89
vulcanite, 125
Flame used in soldering, 50
Flasks for vulcanite work, 104
Flat tooth on pivot, 139
Flat teeth fitted to plate, 80
backing of, 83
prepared for soldering, 86
Folding of plates in swaging, 53
Formulæ for ascertaining amount of alloy required in reducing gold, 213
Franklin, Dr., on vulcanizing, 123
French chalk, 19
Furnaces for gold, 31, 32
continuous gum work, 150, 151
zinc, 26
Fusible metals, 28
Fusing point of metals, 239

GARTRELL'S Gauge, 121
Celluloid Machine, 174
Gee, Mr., to raise gold to higher standard, 216
Godiva composition, 7
Gold, 209
physical properties of, 210
refining by humid process, 211
Gold, formulæ to ascertain amount of alloy for, 213
Gold, fine, unsuitable for base plates, 30
effect of tin, lead, antimony, &c., upon, 38
purified by nitre, 38
purified by chloride of mercury, 38
lemel, treatment of, 39
Gold Alloys, for plate, 217
Gold Alloys, for clasps, 219
solder, 219
Gutta-percha, for impressions, 6
impression cups, 11, 183
plates for biting blocks, 99

HARD models, 13
Harris, Dr., on blowpipe, 47
pivoting, 136
Hayes moulding flask for sand casting, 24
Heater for vulcanite, 109
Hunt, Dr. Finlay, on celluloid, 161
Hydrochloric acid, 259
Hydrocyanic ,, 261
Hydrofluoric ,, 259

IMPRESSIONS, 6, 9
of cleft palate, 182, 194
Impression trays, 2
materials, 5
Ingot moulds, 32
Instrument for dressing between the teeth of vulcanite cases, 125 126
Instruments, tempering of, 253
Investing mixture, 85

KINGSLEY'S method of constructing artificial palates 193

LADLE used in pouring metal 26
for lemel, 39
Lathe for fitting teeth, 81
Lawrence, Dr., on thermometers 121
Lead, casting counters in, 27
properties of, 230
Lemel, treatment of, 39
Lower plates, swaging of, 60
Lycopodium, 19

MAGNET used to extract iron from gold filings, 37
Mallets (horn) for striking up plates, 53
Marker for tube teeth, 91
Measuring, instead of taking impressions of the jaw, 1

Melting gold, 35
zinc, 26
Mercury, 230
purification of, 231
properties of, 231
Metals, properties of, 234
expansion of, 235
specific gravity of, 236—238
Misfitting plates, how to correct, 56
Mixture of resin and wax for models, 17
Models, casting in plaster, 13
casting in sand, 19
for plate, 14, 16
for vulcanite, 14, 103
Moulding sand, 18
Moulds for Dr. Kingsley's artificial palate, 200, 202
Mouth blowpipe, 46

NITRIC acid, 258

OBJECTIONS to certain forms of combination work, 133
Obtaining bites, 74
in vulcanite work, 99
Obturators, 176
Opening flask after vulcanizing, 124
Overheating plaster destructive, 17, 107
zinc, 26

PACKING vulcanite, 109
Palladium, 224
alloys of, 225
Paré, Ambrose, earliest obturator recorded, 177
Partial cases, trays for, 3
models, casting in sand, 21
plates, striking up of, 58
cases in vulcanite, 116
continuous gum, 161
Parting liquids for impressions, 13
Patterns for plates, 52, 58
Perforating pliers, 83
Perforating pliers (Dr. Mallet's), 84
Phosphorus, 260
Pins for supporting plaster teeth, 12
Pivot teeth, 136
Plaster of Paris used as impression material, 8
Plaster of Paris, casting models in, 13
Plates, striking up of, 52
finishing of, 89
Platinum, 223
alloys, 224
Pouring gold, 36, 41
Press for closing vulcanite flasks, 111
Properties of metals, 234
Pumice-stone, 90
Punches for dressing zinc models, 27
(bone) for plate striking, 59
(copper) for chasing, 60
(steel) ,, ,, 61
Punching pliers, 55

REAMUR'S scale to convert to Fahrenheit, 251
Remedies for accidents, 262
Repairing gold plates, 143
vulcanite, 146
Resetting teeth of vulcanite case, 147
Richardson, Dr., on hydrostatic blowpipe, 45
Ridges, upper cases retained by means of, 127
Rifflers for finishing vulcanite, 125, 126
Rising of vulcanite cases, 114
Riveting teeth backs, 84
Roberts, Dr., on continuous gum, 161
Rollers for gold, 41
Rolling or flatting gold, 42
Rouge, used in plate polishing, 90

SAL-AMMONIAC, flux for gold, 37
Sand moulding, 18
Setting mixture for plaster, 8
Shears for plate, 55
Silver, 225
properties of, 226
alloyed with palladium and platinum, 226
Slipping of plates when striking, 56
Soft rubber for artificial palates, 203
Soft soldering liquid, 232
Solders for gold, 219
aluminium, 228

Solders for continuous gum work, 156
Solder, silver, 232
soft, 232
Soldering, 48
flat teeth, 86
teeth in continuous gum work, 156
aluminium, 228
on casting sand, 256
Specific gravity of wax, 107
vulcanite (American) 108
to ascertain, 236
tables for gold and other metals, 237
Steam, elastic force of, 207
Steam-gauge, 121
Stearns' artificial palate, 178
Stent composition, 7
Strengthened plates, 70
Striking up plates, 52
difficult cases of, 53, 59
Suction chambers in plates, 57
vulcanite cases, 103
Sulphur, used to fasten tube teeth, 98
Sulphuric acid, 259
Swivels attached to gold plates, 95
vulcanite sets, 102

TABLE of corresponding temperatures on different thermometer scales, 252
for tempering, 255
specific gravity, 237
of useful numerical data, 255
showing elastic force of steam, 207
Tempering instruments and tools, 253
Thermometers, 121
Thermometer scales, 251
Tomes, Mr., on pivoting, 136
Tough gold, 36
Trays, impression, 2
Trimming plate after swaging, 55
Tube teeth, 90
Type-metal, 29

VALUE of gold of the various carats, table of, 223
Vulcanite, manufacture of, 204
properties of, 123
dentures, 99
firing models for, 103
measuring, 109
packing, 107, 110
thick cases in, 123
finishing, 125
in combination with gold, 129
soft, for artificial palates, 203
obturators and artificial palates, 180
press for closing flask, 111
partial cases in, 116
partial cases, with clasps, 117
cases with ridges, 127
Vulcanite flasks, 104, 113
Vulcanizers, 118—120
Vulcanizing, 122

WARPING of plates, 87
Water of Ayr stone, 89
Watt, Prof., formulæ for ascertaining the amount of alloy required in reducing gold, 214
Wax for impressions, 5
for biting blocks, 74
Waxing plaster models, 17
Weighing alloy for gold, 33, 35
Whitney's flask for vulcanite work, 104
vulcanizer, 120
Wildman, Prof., on vulcanizing, 122
Wire (iron) used with gutta-percha biting plates, 99
Wire (gold), drawing of, 42
Wire clamps, used in soldering, 58, 71
clasps, objections to, 61
Wood pivots, 140

ZINC, properties of, 229
melting and pouring, 26
shrinkage, 28
to prevent splitting of die, 55
sheet used for special impression trays, 4
plates for battery, 244
amalgamation of, 244

PRINTED BY J. S. VIRTUE AND CO., LIMITED, CITY ROAD, LONDON.

WEALE'S SERIES

OF

SCIENTIFIC AND TECHNICAL

WORKS.

"It is not too much to say that no books have ever proved more popular with or more useful to young engineers and others than the excellent treatises comprised in WEALE'S SERIES."—**Engineer.**

A New Classified List.

	PAGE		PAGE
CIVIL ENGINEERING AND SURVEYING	2	ARCHITECTURE AND BUILDING . .	6
MINING AND METALLURGY	3	INDUSTRIAL AND USEFUL ARTS. .	9
MECHANICAL ENGINEERING. . . .	4	AGRICULTURE, GARDENING, ETC. .	10
NAVIGATION, SHIPBUILDING, ETC. .	5	MATHEMATICS, ARITHMETIC, ETC .	12

BOOKS OF REFERENCE AND MISCELLANEOUS VOLUMES . . 14

CROSBY LOCKWOOD AND SON,

7, STATIONERS' HALL COURT, LONDON, E.C.

1900.

CIVIL ENGINEERING & SURVEYING.

Civil Engineering.
By HENRY LAW, M.Inst.C.E. Including a Treatise on HYDRAULIC ENGINEERING by G. R. BURNELL, M.I.C.E. Seventh Edition, revised, with LARGE ADDITIONS by D. K. CLARK, M.I.C.E. . . . 6/6

Pioneer Engineering:
A Treatise on the Engineering Operations connected with the Settlement of Waste Lands in New Countries. By EDWARD DOBSON, M.INST.C.E. With numerous Plates. Second Edition 4/6

Iron Bridges of Moderate Span:
Their Construction and Erection. By HAMILTON W. PENDRED. With 40 Illustrations 2/0

Iron and Steel Bridges and Viaducts.
A Practical Treatise upon their Construction for the use of Engineers, Draughtsmen, and Students. By FRANCIS CAMPIN, C.E. With numerous Illustrations 3/6

Constructional Iron and Steel Work,
As applied to Public, Private, and Domestic Buildings. By FRANCIS CAMPIN, C.E. 3/6

Tubular and other Iron Girder Bridges.
Describing the Britannia and Conway Tubular Bridges. By G. DRYSDALE DEMPSEY, C.E. Fourth Edition 2/0

Materials and Construction:
A Theoretical and Practical Treatise on the Strains, Designing, and Erection of Works of Construction. By FRANCIS CAMPIN, C.E. . . 3/0

Sanitary Work in the Smaller Towns and in Villages.
By CHARLES SLAGG, Assoc. M.Inst.C.E. Third Edition . . 3/0

Roads and Streets (The Construction of).
In Two Parts: I. THE ART OF CONSTRUCTING COMMON ROADS, by H. LAW, C.E., Revised by D. K. CLARK, C.E.; II. RECENT PRACTICE: Including Pavements of Wood, Asphalte, &c. By D. K. CLARK, C.E. 4/6

Gas Works (The Construction of),
And the Manufacture and Distribution of Coal Gas. By S. HUGHES, C.E. Re-written by WILLIAM RICHARDS, C.E. Eighth Edition . . 5/6

Water Works
For the Supply of Cities and Towns. With a Description of the Principal Geological Formations of England as influencing Supplies of Water. By SAMUEL HUGHES, F.G.S., C.E. Enlarged Edition 4/0

The Power of Water,
As applied to drive Flour Mills, and to give motion to Turbines and other Hydrostatic Engines. By JOSEPH GLYNN, F.R.S. New Edition . 2/0

Wells and Well-Sinking.
By JOHN GEO. SWINDELL, A.R.I.B.A., and G. R. BURNELL, C.E. Revised Edition. With a New Appendix on the Qualities of Water. Illustrated 2/0

The Drainage of Lands, Towns, and Buildings.
By G. D. DEMPSEY, C.E. Revised, with large Additions on Recent Practice, by D. K. CLARK, M.I.C.E. Third Edition 4/6

The Blasting and Quarrying of Stone,
For Building and other Purposes. With Remarks on the Blowing up of Bridges. By Gen. Sir J. BURGOYNE, K.C.B. 1/6

Foundations and Concrete Works.
With Practical Remarks on Footings, Planking, Sand, Concrete, Béton, Pile-driving, Caissons and Cofferdams. By E. DOBSON, M.R.I.B.A. Eighth Edition 1/6

Pneumatics,
Including Acoustics and the Phenomena of Wind Currents, for the Use of Beginners. By CHARLES TOMLINSON, F.R.S. Fourth Edition . 1/6

Land and Engineering Surveying.
For Students and Practical Use. By T. BAKER, C.E. Eighteenth Edition, Revised and Extended by F. E. DIXON, A.M. Inst. C.E., Professional Associate of the Institution of Surveyors. With numerous Illustrations and two Lithographic Plates . . . . . *[Just published* 2/0

Mensuration and Measuring.
For Students and Practical Use. With the Mensuration and Levelling of Land for the purposes of Modern Engineering. By T. BAKER, C.E. New Edition by E. NUGENT, C.E. 1/6

MINING AND METALLURGY.

Mineralogy,
Rudiments of. By A. RAMSAY, F.G.S. Fourth Edition, revised and enlarged. Woodcuts and Plates 3/6

Coal and Coal Mining,
A Rudimentary Treatise on. By the late Sir WARINGTON W. SMYTH, F.R.S. Eighth Edition, revised and extended by T. FORSTER BROWN. *[Just published* 3/6

Metallurgy of Iron.
Containing Methods of Assay, Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c. By H. BAUERMAN, F.G.S. With numerous Illustrations. Sixth Edition, revised and enlarged 5/0

The Mineral Surveyor and Valuer's Complete Guide.
By W. LINTERN. Fourth Edition, with an Appendix on Magnetic and Angular Surveying 3/6

Slate and Slate Quarrying:
Scientific, Practical, and Commercial. By D. C. DAVIES, F.G.S. With numerous Illustrations and Folding Plates. Fourth Edition . . 3/0

A First Book of Mining and Quarrying,
With the Sciences connected therewith, for Primary Schools and Self Instruction. By J. H. COLLINS, F.G.S. Second Edition . . . 1/6

Subterraneous Surveying,
With and without the Magnetic Needle. By T. FENWICK and T. BAKER, C.E. Illustrated 2/6

Mining Tools.
Manual of. By WILLIAM MORGANS, Lecturer on Practical Mining at the Bristol School of Mines 2/6

Mining Tools, Atlas
Of Engravings to Illustrate the above, containing 235 Illustrations of Mining Tools, drawn to Scale. 4to 4/6

Physical Geology,
Partly based on Major-General PORTLOCK's "Rudiments of Geology." By RALPH TATE, A.L.S., &c. Woodcuts. 2/0

Historical Geology,
Partly based on Major-General PORTLOCK's "Rudiments." By RALPH TATE, A.L.S., &c. Woodcuts 2/6

Geology, Physical and Historical.
Consisting of "Physical Geology," which sets forth the Leading Principles of the Science; and "Historical Geology," which treats of the Mineral and Organic Conditions of the Earth at each successive epoch. By RALPH TATE, F.G.S. 4/6

Electro-Metallurgy,
Practically Treated. By ALEXANDER WATT. Tenth Edition, enlarged and revised, including the most Recent Processes 3/6

MECHANICAL ENGINEERING.

The Workman's Manual of Engineering Drawing.
By JOHN MAXTON, Instructor in Engineering Drawing, Royal Naval College, Greenwich. Seventh Edition. 300 Plates and Diagrams . 3/6

Fuels: Solid, Liquid, and Gaseous.
Their Analysis and Valuation. For the Use of Chemists and Engineers. By H. J. PHILLIPS, F.C.S., formerly Analytical and Consulting Chemist to the Great Eastern Railway. Third Edition 2/0

Fuel, Its Combustion and Economy.
Consisting of an Abridgment of "A Treatise on the Combustion of Coal and the Prevention of Smoke." By C. W. WILLIAMS, A.I.C.E. With Extensive Additions by D. K. CLARK, M.Inst.C.E. Fourth Edition . 3/6

The Boilermaker's Assistant
in Drawing, Templating, and Calculating Boiler Work, &c. By J. COURTNEY, Practical Boilermaker. Edited by D. K. CLARK, C.E. . 2/0

The Boiler-Maker's Ready Reckoner,
With Examples of Practical Geometry and Templating for the Use of Platers, Smiths, and Riveters. By JOHN COURTNEY. Edited by D. K. CLARK, M.I.C.E. Fourth Edition 4/0

*** *The last two Works in One Volume, half-bound, entitled* "THE BOILER-MAKER'S READY-RECKONER AND ASSISTANT." By J. COURTNEY and D. K. CLARK. *Price* 7/0.

Steam Boilers:
Their Construction and Management. By R. ARMSTRONG, C.E. Illustrated 1/6

Steam and Machinery Management.
A Guide to the Arrangement and Economical Management of Machinery. By M. POWIS BALE, M.Inst.M.E. 2/6

Steam and the Steam Engine,
Stationary and Portable. Being an Extension of the Treatise on the Steam Engine of Mr. J. SEWELL. By D. K. CLARK, C.E. Fourth Edition 3/6

The Steam Engine,
A Treatise on the Mathematical Theory of, with Rules and Examples for Practical Men. By T. BAKER, C.E. 1/6

The Steam Engine.
By Dr. LARDNER. Illustrated 1/6

Locomotive Engines,
By G. D. DEMPSEY, C.E. With large Additions treating of the Modern Locomotive, by D. K. CLARK, M.Inst.C.E. 3/0

Locomotive Engine-Driving.
A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS. Tenth Edition. 3*s.* 6*d.* limp; cloth boards . 4/6

Stationary Engine-Driving.
A Practical Manual for Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS. Sixth Edition. 3*s.* 6*d.* limp; cloth boards . 4/6

The Smithy and Forge.
Including the Farrier's Art and Coach Smithing. By W. J. E. CRANE. Fourth Edition 2/6

Modern Workshop Practice,
As applied to Marine, Land, and Locomotive Engines, Floating Docks, Dredging Machines, Bridges, Ship-building, &c. By J. G. WINTON. Fourth Edition, Illustrated 3/6

Mechanical Engineering.
Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Mechanical Manipulation, Manufacture of the Steam Engine, &c. By FRANCIS CAMPIN, C.E. Third Edition 2/6

Details of Machinery.
Comprising Instructions for the Execution of various Works in Iron in the Fitting-Shop, Foundry, and Boiler-Yard. By FRANCIS CAMPIN, C.E. 3/0

Elementary Engineering:
A Manual for Young Marine Engineers and Apprentices. In the Form of Questions and Answers on Metals, Alloys, Strength of Materials, &c. By J. S. BREWER. Fourth Edition 1/6

Power in Motion:
Horse-power Motion, Toothed-Wheel Gearing, Long and Short Driving Bands, Angular Force, &c. By JAMES ARMOUR, C.E. Third Edition 2/0

Iron and Heat,
Exhibiting the Principles concerned in the Construction of Iron Beams, Pillars, and Girders. By J. ARMOUR, C.E. 2/6

Practical Mechanism,
And Machine Tools. By T. BAKER, C.E. With Remarks on Tools and Machinery, by J. NASMYTH, C.E. 2/6

Mechanics:
Being a concise Exposition of the General Principles of Mechanical Science, and their Applications. By CHARLES TOMLINSON, F.R.S. . . 1/6

Cranes (The Construction of),
And other Machinery for Raising Heavy Bodies for the Erection of Buildings, &c. By JOSEPH GLYNN, F.R.S. 1/6

NAVIGATION, SHIPBUILDING, ETC.

The Sailor's Sea Book:
A Rudimentary Treatise on Navigation. By JAMES GREENWOOD, B.A. With numerous Woodcuts and Coloured Plates. New and enlarged Edition. By W. H. ROSSER 2/6

Practical Navigation.
Consisting of THE SAILOR'S SEA-BOOK, by JAMES GREENWOOD and W. H. ROSSER; together with Mathematical and Nautical Tables for the Working of the Problems, by HENRY LAW, C.E., and Prof. J. R. YOUNG. 7/0

Navigation and Nautical Astronomy,
In Theory and Practice. By Prof. J. R. YOUNG. New Edition. 2/6

Mathematical Tables,
For Trigonometrical, Astronomical, and Nautical Calculations; to which is prefixed a Treatise on Logarithms. By H. LAW, C.E. Together with a Series of Tables for Navigation and Nautical Astronomy. By Professor J. R. YOUNG. New Edition 4/0

Masting, Mast-Making, and Rigging of Ships.
Also Tables of Spars, Rigging, Blocks; Chain, Wire, and Hemp Ropes, &c., relative to every class of vessels. By ROBERT KIPPING, N.A. . 2/0

Sails and Sail-Making.
With Draughting, and the Centre of Effort of the Sails. By ROBERT KIPPING, N.A. 2/6

Marine Engines and Steam Vessels.
By R. MURRAY, C.E. Eighth Edition, thoroughly revised, with Additions by the Author and by GEORGE CARLISLE, C.E. 4/6

Naval Architecture:
An Exposition of Elementary Principles. By JAMES PEAKE . . 3/6

Ships for Ocean and River Service,
Principles of the Construction of. By HAKON A. SOMMERFELDT . 1/6

Atlas of Engravings
To Illustrate the above. Twelve large folding Plates. Royal 4to, cloth 7/6

The Forms of Ships and Boats.
By W. BLAND. Ninth Edition, with numerous Illustrations and Models 1/6

ARCHITECTURE AND THE BUILDING ARTS.

Constructional Iron and Steel Work,
As applied to Public, Private, and Domestic Buildings. By FRANCIS CAMPIN, C.E. 3/6

Building Estates:
A Treatise on the Development, Sale, Purchase, and Management of Building Land. By F. MAITLAND. Third Edition 2/0

The Science of Building:
An Elementary Treatise on the Principles of Construction. By E. WYNDHAM TARN, M.A. Lond. Fourth Edition 3/6

The Art of Building:
General Principles of Construction, Strength, and Use of Materials, Working Drawings, Specifications, &c. By EDWARD DOBSON, M.R.I.B.A. . 2/0

A Book on Building,
Civil and Ecclesiastical. By Sir EDMUND BECKETT, Q.C. (Lord GRIMTHORPE). Second Edition 4/6

Dwelling-Houses (The Erection of),
Illustrated by a Perspective View, Plans, and Sections of a Pair of Villas, with Specification, Quantities, and Estimates. By S. H. BROOKS, Architect 2/6

Cottage Building.
By C. BRUCE ALLEN. Eleventh Edition, with Chapter on Economic Cottages for Allotments, by E. E. ALLEN, C.E. 2/0

Acoustics in Relation to Architecture and Building:
The Laws of Sound as applied to the Arrangement of Buildings. By Professor T. ROGER SMITH, F.R.I.B.A. New Edition, Revised . . 1/6

The Rudiments of Practical Bricklaying.
General Principles of Bricklaying; Arch Drawing, Cutting, and Setting; Pointing; Paving, Tiling, &c. By ADAM HAMMOND. With 68 Woodcuts 1/6

The Art of Practical Brick Cutting and Setting.
By ADAM HAMMOND. With 90 Engravings 1/6

Brickwork:
A Practical Treatise, embodying the General and Higher Principles of Bricklaying, Cutting and Setting; with the Application of Geometry to Roof Tiling, &c. By F. WALKER 1/6

Bricks and Tiles,
Rudimentary Treatise on the Manufacture of; containing an Outline of the Principles of Brickmaking. By E. DOBSON, M.R.I.B.A. Additions by C. TOMLINSON, F.R.S. Illustrated 3/0

The Practical Brick and Tile Book.
Comprising: BRICK AND TILE MAKING, by E. DOBSON, M.INST.C.E.; Practical BRICKLAYING, by A. HAMMOND; BRICK-CUTTING AND SETTING, by A. HAMMOND. 550 pp. with 270 Illustrations, half-bound . . 6/0

Carpentry and Joinery—
THE ELEMENTARY PRINCIPLES OF CARPENTRY. Chiefly composed from the Standard Work of THOMAS TREDGOLD, C.E. With Additions, and TREATISE ON JOINERY, by E. W. TARN, M.A. Seventh Edition . . . 3/6

Carpentry and Joinery—Atlas
Of 35 Plates to accompany and Illustrate the foregoing book. With Descriptive Letterpress. 4to 6/0

A Practical Treatise on Handrailing;
Showing New and Simple Methods. By GEO. COLLINGS. Second Edition, Revised, including a TREATISE ON STAIRBUILDING. With Plates . 2/6

Circular Work in Carpentry and Joinery.
A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS. Third Edition 2/6

Roof Carpentry:
Practical Lessons in the Framing of Wood Roofs. For the Use of Working Carpenters. By GEO. COLLINGS 2/0

The Construction of Roofs of Wood and Iron;
Deduced chiefly from the Works of Robison, Tredgold, and Humber. By E. WYNDHAM TARN, M.A., Architect. Third Edition . . . 1/6

The Joints Made and Used by Builders.
By WYVILL J. CHRISTY, Architect. With 160 Woodcuts . . 3/0

Shoring
And its Application: A Handbook for the Use of Students. By GEORGE H. BLAGROVE. With 31 Illustrations 1/6

The Timber Importer's, Timber Merchant's, and Builder's Standard Guide.
By R. E. GRANDY 2/0

Plumbing:
A Text-Book to the Practice of the Art or Craft of the Plumber. With Chapters upon House Drainage and Ventilation. By WM. PATON BUCHAN. Eighth Edition, Re-written and Enlarged, with 500 Illustrations . 3/6

Ventilation:
A Text Book to the Practice of the Art of Ventilating Buildings. By W. P. BUCHAN, R.P., Author of "Plumbing," &c. With 170 Illustrations 3/6

The Practical Plasterer:
A Compendium of Plain and Ornamental Plaster Work. By W. KEMP 2/0

House Painting, Graining, Marbling, & Sign Writing.
With a Course of Elementary Drawing, and a Collection of Useful Receipts. By ELLIS A. DAVIDSON. Seventh Edition. Coloured Plates . . 5/0

*** *The above, in cloth boards, strongly bound,* 6/0

A Grammar of Colouring.
Applied to Decorative Painting and the Arts. By GEORGE FIELD. New Edition, enlarged, by ELLIS A. DAVIDSON. With Coloured Plates . 3/0

Elementary Decoration
As applied to Dwelling Houses, &c. By JAMES W. FACEY. Illustrated 2/0

Practical House Decoration.
A Guide to the Art of Ornamental Painting, the Arrangement of Colours in Apartments, and the Principles of Decorative Design. By JAMES W. FACEY. 2/6

*** *The last two Works in One handsome Vol., half-bound, entitled* "HOUSE DECORATION, ELEMENTARY AND PRACTICAL," *price* 5/0

Portland Cement for Users.
By HENRY FAIJA, A.M.Inst.C.E. Third Edition, Corrected . . 2/0

Limes, Cements, Mortars, Concretes, Mastics, Plastering, &c.
By G. R. BURNELL C.E. Fifteenth Edition 1/6

Masonry and Stone-Cutting.
The Principles of Masonic Projection and their application to Construction. By EDWARD DOBSON, M.R.I.B.A. 2/6

Arches, Piers, Buttresses, &c.:
Experimental Essays on the Principles of Construction. By W. BLAND. 1/6

Quantities and Measurements.
In Bricklayers', Masons', Plasterers', Plumbers', Painters', Paperhangers', Gilders', Smiths', Carpenters' and Joiners' Work. By A. C. BEATON 1/6

The Complete Measurer:
Setting forth the Measurement of Boards, Glass, Timber and Stone. By R. HORTON. Sixth Edition 4/0

**** *The above, strongly bound in leather, price* 5/0.

Light:
An Introduction to the Science of Optics. Designed for the Use of Students of Architecture, Engineering, and other Applied Sciences. By E. WYNDHAM TARN, M.A., Author of "The Science of Building," &c. . . 1/6

Hints to Young Architects.
By GEORGE WIGHTWICK, Architect. Sixth Edition, revised and enlarged by G. HUSKISSON GUILLAUME, Architect 3/6

Architecture—Orders:
The Orders and their Æsthetic Principles. By W. H. LEEDS. Illustrated. 1/6

Architecture—Styles:
The History and Description of the Styles of Architecture of Various Countries, from the Earliest to the Present Period. By T. TALBOT BURY, F.R.I.B.A. Illustrated 2/0

**** ORDERS AND STYLES OF ARCHITECTURE, *in One Vol.*, 3/6.

Architecture—Design:
The Principles of Design in Architecture, as deducible from Nature and exemplified in the Works of the Greek and Gothic Architects. By PROF. LACY GARRETT, Architect. Illustrated 2/6

**** *The three preceding Works in One handsome Vol., half bound, entitled* "MODERN ARCHITECTURE," *price* 6/0.

Perspective for Beginners.
Adapted to Young Students and Amateurs in Architecture, Painting, &c. By GEORGE PYNE 2/0

Architectural Modelling in Paper.
By T. A. RICHARDSON. With Illustrations, engraved by O. JEWITT 1/6

Glass Staining, and the Art of Painting on Glass.
From the German of Dr. GERARD and EMANUEL OTTO FROMBERG. With an Appendix on THE ART OF ENAMELLING 2/6

Vitruvius—The Architecture of.
In Ten Books. Translated from the Latin by JOSEPH GWILT, F.S.A., F.R.A.S. With 23 Plates 5/0

N.B.—This is the only Edition of VITRUVIUS *procurable at a moderate price*

Grecian Architecture.
An Inquiry into the Principles of Beauty in. With an Historical View of the Rise and Progress of the Art in Greece. By the EARL OF ABERDEEN 1/0

**** *The two preceding Works in One handsome Vol., half bound, entitled* "ANCIENT ARCHITECTURE," *price* 6/0.

INDUSTRIAL AND USEFUL ARTS.

Cements, Pastes, Glues, and Gums.
A Practical Guide to the Manufacture and Application of the various Agglutinants required for Workshop, Laboratory, or Office Use. With upwards of 900 Recipes and Formulæ. By H. C. STANDAGE . . 2/0

Clocks and Watches, and Bells,
A Rudimentary Treatise on. By Sir EDMUND BECKETT, Q.C. (Lord GRIMTHORPE). Seventh Edition 4/6

The Goldsmith's Handbook.
Containing full Instructions in the Art of Alloying, Melting, Reducing, Colouring, Collecting and Refining, Recovery of Waste, Solders, Enamels, &c., &c. By GEORGE E. GEE. Fifth Edition 3/0

The Silversmith's Handbook,
On the same plan as the GOLDSMITH'S HANDBOOK. By GEORGE E. GEE. Third Edition 3/0
*** *The last two Works, in One handsome Vol, half-bound,* 7/0.

The Hall-Marking of Jewellery.
Comprising an account of all the different Assay Towns of the United Kingdom; with the Stamps and Laws relating to the Standards and Hall-Marks at the various Assay Offices. By GEORGE E. GEE . . 3/0

French Polishing and Enamelling.
A Practical Work of Instruction, including numerous Recipes for making Polishes, Varnishes, Glaze-Lacquers, Revivers, &c. By R. BITMEAD. [*Just Published.* 1/6

Practical Organ Building.
By W. E. DICKSON, M.A. Second Edition, Revised, with Additions 2/6

Coach-Building:
A Practical Treatise. By JAMES W. BURGESS. With 57 Illustrations 2/6

The Brass Founder's Manual:
Instructions for Modelling, Pattern Making, Moulding, Turning, &c. By W. GRAHAM 2/0

The Sheet-Metal Worker's Guide.
A Practical Handbook for Tinsmiths, Coppersmiths, Zincworkers, &c., with 46 Diagrams. By W. J. E. CRANE. Third Edition, revised . . 1/6

Sewing Machinery:
Its Construction, History, &c. With full Technical Directions for Adjusting, &c. By J. W. URQUHART, C.E. 2/0

Gas Fitting:
A Practical Handbook. By JOHN BLACK. New Edition . . 2/6

Construction of Door Locks.
From the Papers of A. C. HOBBS. Edited by C. TOMLINSON, F.R.S 2/6

The Model Locomotive Engineer, Fireman, and Engine-Boy.
Comprising an Historical Notice of the Pioneer Locomotive Engines and their Inventors. By MICHAEL REYNOLDS 3/6

The Art of Letter Painting made Easy.
By J. G. BADENOCH. With 12 full-page Engravings of Examples . 1/6

The Art of Boot and Shoemaking.
Including Measurement, Last-fitting, Cutting-out, Closing and Making. By JOHN BEDFORD LENO. With numerous Illustrations. Fourth Edition 2/0

Mechanical Dentistry:
A Practical Treatise on the Construction of the Various Kinds of Artificial Dentures. By CHARLES HUNTER. Fourth Edition . . . 3/0

Wood Engraving:
A Practical and Easy Introduction to the Art. By W. N. BROWN . 1/6

Laundry Management.
A Handbook for Use in Private and Public Laundries. By the EDITOR of "The Laundry Journal." 2/0

AGRICULTURE, GARDENING, ETC.

Draining and Embanking:
A Practical Treatise. By Prof. JOHN SCOTT. With 68 Illustrations 1/6

Irrigation and Water Supply:
A Practical Treatise on Water Meadows, Sewage Irrigation, Warping, &c.; on the Construction of Wells, Ponds, Reservoirs, &c. By Prof. JOHN SCOTT. With 34 Illustrations 1/6

Farm Roads, Fences, and Gates:
A Practical Treatise on the Roads, Tramways, and Waterways of the Farm; the Principles of Enclosures; and the different kinds of Fences, Gates, and Stiles. By Prof. JOHN SCOTT. With 75 Illustrations . 1/6

Farm Buildings:
A Practical Treatise on the Buildings necessary for various kinds of Farms, their Arrangement and Construction, with Plans and Estimates. By Prof. JOHN SCOTT. With 105 Illustrations 2/0

Barn Implements and Machines:
Treating of the Application of Power and Machines used in the Threshing-barn, Stockyard, Dairy, &c. By Prof. J. SCOTT. With 123 Illustrations. 2/0

Field Implements and Machines:
With Principles and Details of Construction and Points of Excellence, their Management, &c. By Prof. JOHN SCOTT. With 138 Illustrations 2/0

Agricultural Surveying:
A Treatise on Land Surveying, Levelling, and Setting-out; with Directions for Valuing Estates. By Prof. J. SCOTT. With 62 Illustrations . 1/6

Farm Engineering.
By Professor JOHN SCOTT. Comprising the above Seven Volumes in One, 1,150 pages, and over 600 Illustrations. Half-bound . . . 12/0

Outlines of Farm Management.
Treating of the General Work of the Farm; Stock; Contract Work; Labour, &c. By R. SCOTT BURN 2/6

Outlines of Landed Estates Management.
Treating of the Varieties of Lands, Methods of Farming, Setting-out of Farms, Roads, Fences, Gates, Drainage, &c. By R. SCOTT BURN. 2/6
*** *The above Two Vols. in One, handsomely half-bound, price* 6/0

Soils, Manures, and Crops.
(Vol. I. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN . 2/0

Farming and Farming Economy.
(Vol. II. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN 3/0

Stock: Cattle, Sheep, and Horses.
(Vol. III. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN 2/6

Dairy, Pigs, and Poultry.
(Vol. IV. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN 2/0

Utilization of Sewage, Irrigation, and Reclamation of Waste Land.
(Vol. V. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN . 2/6

Outlines of Modern Farming.
By R. SCOTT BURN. Consisting of the above Five Volumes in One, 1,250 pp., profusely Illustrated, half-bound 12/0

Book-keeping for Farmers and Estate Owners.
A Practical Treatise, presenting, in Three Plans, a System adapted for all classes of Farms. By J. M. WOODMAN. Third Edition, revised . 2/6

Ready Reckoner for the Admeasurement of Land.
By A. ARMAN. Fourth Edition, revised and extended by C. NORRIS 2/0

Miller's, Corn Merchant's, and Farmer's Ready Reckoner.
Second Edition, revised, with a Price List of Modern Flour Mill Machinery, by W. S. HUTTON, C.E. 2/0

The Hay and Straw Measurer.
New Tables for the Use of Auctioneers, Valuers, Farmers, Hay and Straw Dealers, &c. By JOHN STEELE 2/0

Meat Production.
A Manual for Producers, Distributors, and Consumers of Butchers' Meat. By JOHN EWART 2/6

Sheep:
The History, Structure, Economy, and Diseases of. By W. C. SPOONER, M.R.V.S. Fifth Edition, with fine Engravings. 3/6

Market and Kitchen Gardening.
By C. W. SHAW, late Editor of "Gardening Illustrated" . . . 3/0

Kitchen Gardening Made Easy.
Showing the best means of Cultivating every known Vegetable and Herb, &c., with directions for management all the year round. By GEORGE M. F. GLENNY. Illustrated 1/6

Cottage Gardening:
Or Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAY. 1/6

Garden Receipts.
Edited by CHARLES W. QUIN 1/6

Fruit Trees,
The Scientific and Profitable Culture of. From the French of M. DU BREUIL. Fifth Edition, carefully Revised by GEORGE GLENNY. With 187 Woodcuts 3/6

The Tree Planter and Plant Propagator:
With numerous Illustrations of Grafting, Layering, Budding, Implements, Houses, Pits, &c. By SAMUEL WOOD 2/0

The Tree Pruner:
A Practical Manual on the Pruning of Fruit Trees, Shrubs, Climbers, and Flowering Plants. With numerous Illustrations. By SAMUEL WOOD 1/6

*** *The above Two Vols. in One, handsomely half-bound, price* 3/6

The Art of Grafting and Budding.
By CHARLES BALTET. With Illustrations 2/6

BRITISH MINING.

A Treatise on the History, Discovery, Practical Development, and Future Prospects of Metalliferous Mines in the United Kingdom. By ROBERT HUNT, F.R.S., late Keeper of Mining Records. Upwards of 950 pp., with 250 Illustrations. Second Edition, Revised. Super-royal 8vo, cloth **£2 2s.**

"The book is a treasure-house of statistical information on mining subjects, and we know of no other work embodying so great a mass of matter of this kind. Were this the only merit of Mr. Hunt's volume it would be sufficient to render it indispensable in the library of every one interested in the development of the mining and metallurgical industries of this country."—*Athenæum.*

MINE DRAINAGE.

A Complete Practical Treatise on Direct-Acting Underground Steam Pumping Machinery. By STEPHEN MICHELL. Second Edition, Re-written and Enlarged, 300 pp. With about 250 Illustrations. Royal 8vo, cloth.

[*Just Published.* *Net* **25/0**

SUMMARY OF CONTENTS.—HORIZONTAL PUMPING ENGINES.—ROTARY AND NON-ROTARY HORIZONTAL ENGINES.—SIMPLE AND COMPOUND STEAM PUMPS.—VERTICAL PUMPING ENGINES.—ROTARY AND NON-ROTARY VERTICAL ENGINES.—SIMPLE AND COMPOUND STEAM PUMPS.—TRIPLE EXPANSION STEAM PUMPS.—PULSATING STEAM PUMPS.—PUMP VALVES.—SINKING PUMPS, &c., &c.

"This volume contains an immense amount of information and interesting new matter. The book should undoubtedly prove of great use to all who wish for information on the subject, inasmuch as the different patterns of steam pumps are not alone lucidly described and clearly illustrated, but in addition numerous tables are supplied, in which their sizes, capacity, price, &c., are set forth, hence facilitating immensely the rational selection of a pump to suit any purpose that the reader may desire, or, on the other hand, supplying him with useful information about any of the pumps that come within the scope of the volume."—*The Engineer.*

THE PROSPECTOR'S HANDBOOK.

A Guide for the Prospector and Traveller in search of Metal-Bearing or other Valuable Minerals. By J. W. ANDERSON, M.A. (Camb.), F.R.G.S., Author of "Fiji and New Caledonia." Eighth Edition, thoroughly Revised and much Enlarged. Small crown 8vo, cloth, **3/6**; or, leather, pocket-book form, with tuck. [*Just Published.* **4/6**

"Will supply a much-felt want, especially among Colonists, in whose way are so often thrown many mineralogical specimens the value of which it is difficult to determine."—*Engineer.*

"How to find commercial minerals, and how to identify them when they are found, are the leading points to which attention is directed. The author has managed to pack as much practical detail into his pages as would supply material for a book three times its size."—*Mining Journal.*

NOTES AND FORMULÆ FOR MINING STUDENTS.

By JOHN HERMAN MERIVALE, M.A., Late Professor of Mining in the Durham College of Science, Newcastle-upon-Tyne. Fourth Edition, Revised and Enlarged. By H. F. BULMAN, A.M.Inst.C.E. Small crown 8vo, cloth.

[*Just Published.* **2/6**

"The author has done his work in a creditable manner, and has produced a book that will be of service to students and those who are practically engaged in mining operations."—*Engineer.*

THE MINER'S HANDBOOK.

A Handy Book of Reference on the subjects of Mineral Deposits, Mining Operations, Ore Dressing, &c. For the Use of Students and others interested in Mining Matters. By JOHN MILNE, F.R.S., Professor of Mining in the Imperial University of Japan. Revised Edition. Fcap. 8vo, leather . **7/6**

"Professor Milne's handbook is sure to be received with favour by all connected with mining, and will be extremely popular among students."—*Athenæum.*

POCKET-BOOK FOR MINERS AND METALLURGISTS.

Comprising Rules, Formulæ, Tables, and Notes for Use in Field and Office Work. By F. DANVERS POWER, F.G.S., M.E. Second Edition, Corrected. Fcap. 8vo, leather. [*Just Published.* **9/0**

"This excellent book is an admirable example of its kind, and ought to find a large sale amongst English-speaking prospectors and mining engineers."—*Engineering.*

FIELD TESTING FOR GOLD AND SILVER.

A Practical Manual for Prospectors and Miners. By W. H. MERRITT, M.N.E. Inst. M.E., A.R.S.M., &c. With Photographic Plates and other Illustrations. Fcap. 8vo, leather. [*Just Published.* *Net* **5/0**

MATHEMATICS, ARITHMETIC, ETC.

Descriptive Geometry,
An Elementary Treatise on; with a Theory of Shadows and of Perspective, extracted from the French of G. MONGE. To which is added a Description of the Principles and Practice of Isometrical Projection. By J. F. HEATHER, M.A. With 14 Plates 2/0

Practical Plane Geometry:
Giving the Simplest Modes of Constructing Figures contained in one Plane and Geometrical Construction of the Ground. By J. F. HEATHER, M.A. With 215 Woodcuts 2/0

Analytical Geometry and Conic Sections,
A Rudimentary Treatise on. By JAMES HANN. A New Edition, re-written and enlarged by Professor J. R. YOUNG 2/0

Euclid (The Elements of).
With many Additional Propositions and Explanatory Notes; to which is prefixed an Introductory Essay on Logic. By HENRY LAW, C.E. . 2/6

*** Sold also separately, viz.:—*

Euclid. The First Three Books. By HENRY LAW, C.E. . . . 1/6
Euclid. Books 4, 5, 6, 11, 12. By HENRY LAW, C.E. . . 1/6

Plane Trigonometry,
The Elements of. By JAMES HANN. 1/6

Spherical Trigonometry,
The Elements of. By JAMES HANN. Revised by CHARLES H. DOWLING, C.E. 1/0
*** Or with "The Elements of Plane Trigonometry," in One Volume,* 2/6

Differential Calculus,
Elements of the. By W. S. B. WOOLHOUSE, F.R.A.S., &c. . . 1/6

Integral Calculus.
By HOMERSHAM COX, B.A. 1/3

Algebra,
The Elements of. By JAMES HADDON, M.A. With Appendix, containing Miscellaneous Investigations, and a Collection of Problems . . 2/0

A Key and Companion to the Above.
An extensive Repository of Solved Examples and Problems in Algebra. By J. R. YOUNG 1/6

Commercial Book-keeping.
With Commercial Phrases and Forms in English, French, Italian, and German. By JAMES HADDON, M.A. 1/6

Arithmetic,
A Rudimentary Treatise on. With full Explanations of its Theoretical Principles, and numerous Examples for Practice. For the Use of Schools and for Self-Instruction. By J. R. YOUNG, late Professor of Mathematics in Belfast College. Thirteenth Edition 1/6

A Key to the Above.
By J. R. YOUNG 1/6

Equational Arithmetic,
Applied to Questions of Interest, Annuities, Life Assurance, and General Commerce; with various Tables by which all Calculations may be greatly facilitated. By W. HIPSLEY 1/6

Arithmetic.
Rudimentary, for the Use of Schools and Self-Instruction. By JAMES HADDON, M.A. Revised by ABRAHAM ARMAN 1/6

A Key to the Above.
By A. ARMAN 1/6

Mathematical Instruments:
Their Construction, Adjustment, Testing, and Use concisely Explained. By J. F. HEATHER, M.A., of the Royal Military Academy, Woolwich. Fourteenth Edition, Revised, with Additions, by A. T. WALMISLEY, M.I.C.E. Original Edition, in 1 vol., Illustrated 2/0

*** *In ordering the above, be careful to say "Original Edition," or give the number in the Series* (32), *to distinguish it from the Enlarged Edition in* 3 *vols. (as follows)—*

Drawing and Measuring Instruments.
Including—I. Instruments employed in Geometrical and Mechanical Drawing, and in the Construction, Copying, and Measurement of Maps and Plans. II. Instruments used for the purposes of Accurate Measurement, and for Arithmetical Computations. By J. F. HEATHER, M.A. . 1/6

Optical Instruments.
Including (more especially) Telescopes, Microscopes, and Apparatus for producing copies of Maps and Plans by Photography. By J. F. HEATHER, M.A. Illustrated 1/6

Surveying and Astronomical Instruments.
Including—I. Instruments used for Determining the Geometrical Features of a portion of Ground. II. Instruments employed in Astronomical Observations. By J. F. HEATHER, M.A. Illustrated. . . . 1/6

*** *The above three volumes form an enlargement of the Author's original work, "Mathematical Instruments," price* 2/0. (*Described at top of page.*)

Mathematical Instruments:
Their Construction, Adjustment, Testing and Use. Comprising Drawing, Measuring, Optical, Surveying, and Astronomical Instruments. By J. F. HEATHER, M.A. Enlarged Edition, for the most part entirely re-written. The Three Parts as above, in One thick Volume. 4/6

The Slide Rule, and How to Use It.
Containing full, easy, and simple Instructions to perform all Business Calculations with unexampled rapidity and accuracy. By CHARLES HOARE, C.E. With a Slide Rule, in tuck of cover. Seventh Edition . . 2/6

Logarithms.
With Mathematical Tables for Trigonometrical, Astronomical, and Nautical Calculations. By HENRY LAW, C.E. Revised Edition . . . 3/0

Compound Interest and Annuities (Theory of).
With Tables of Logarithms for the more Difficult Computations of Interest, Discount, Annuities, &c., in all their Applications and Uses for Mercantile and State Purposes. By FEDOR THOMAN, Paris. Fourth Edition . 4/0

Mathematical Tables,
For Trigonometrical, Astronomical, and Nautical Calculations; to which is prefixed a Treatise on Logarithms. By H. LAW, C.E. Together with a Series of Tables for Navigation and Nautical Astronomy. By Professor J. R. YOUNG. New Edition 4/0

Mathematics,
As applied to the Constructive Arts. By FRANCIS CAMPIN, C.E., &c. Third Edition 3/0

Astronomy.
By the late Rev. ROBERT MAIN, F.R.S. Third Edition, revised and corrected to the Present Time. By W. T. LYNN, F.R.A.S. . . . 2/0

Statics and Dynamics.
The Principles and Practice of. Embracing also a clear development of Hydrostatics, Hydrodynamics, and Central Forces. By T. BAKER, C.E. Fourth Edition 1/6

BOOKS OF REFERENCE AND MISCELLANEOUS VOLUMES.

A Dictionary of Painters, and Handbook for Picture Amateurs.
Being a Guide for Visitors to Public and Private Picture Galleries, and for Art-Students, including Glossary of Terms, Sketch of Principal Schools of Painting, &c. By PHILIPPE DARYL, B.A. 2/6

Painting Popularly Explained.
By T. J. GULLICK, Painter, and JOHN TIMBS, F.S.A. Including Fresco, Oil, Mosaic, Water Colour, Water-Glass, Tempera Encaustic, Miniature, Painting on Ivory, Vellum, Pottery, Enamel, Glass, &c. Sixth Edition 5/0

A Dictionary of Terms used in Architecture, Building, Engineering, Mining, Metallurgy, Archæology, the Fine Arts, &c.
By JOHN WEALE. Sixth Edition. Edited by R. HUNT, F.R.S. . 5/0

Music:
A Rudimentary and Practical Treatise. With numerous Examples. By CHARLES CHILD SPENCER 2/6

Pianoforte,
The Art of Playing the. With numerous Exercises and Lessons. By CHARLES CHILD SPENCER 1/6

The House Manager.
A Guide to Housekeeping, Cookery, Pickling and Preserving, Household Work, Dairy Management, Cellarage of Wines, Home-brewing and Wine-making, Gardening, &c. By AN OLD HOUSEKEEPER . . 3/6

Manual of Domestic Medicine.
By R. GOODING, M.D. Intended as a Family Guide in all cases of Accident and Emergency. Third Edition, carefully revised . . 2/0

Management of Health.
A Manual of Home and Personal Hygiene. By Rev. JAMES BAIRD 1/0

Natural Philosophy,
For the Use of Beginners. By CHARLES TOMLINSON, F.R.S. . . 1/6

The Elementary Principals of Electric Lighting.
By ALAN A. CAMPBELL SWINTON, M.Inst.C.E., M.I.E.E. Fourth Edition, Revised . . . . . [*Just Published* 1/6

The Electric Telegraph,
Its History and Progress. By R. SABINE, C.E., F.S.A., &c. . . 3/0

Handbook of Field Fortification.
By Major W. W. KNOLLYS, F.R.G.S. With 163 Woodcuts . . 3/0

Logic,
Pure and Applied. By S. H. EMMENS. Third Edition . . . 1/6

Locke on the Human Understanding,
Selections from. With Notes by S. H. EMMENS 1/6

The Compendious Calculator
(*Intuitive Calculations*). Or Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions; together with Useful Tables, &c. By DANIEL O'GORMAN. Twenty-seventh Edition, carefully revised by C. NORRIS . . . 2/6

Measures, Weights, and Moneys of all Nations.
With an Analysis of the Christian, Hebrew, and Mahometan Calendars. By W. S. B. WOOLHOUSE, F.R.A.S, F.S.S. Seventh Edition . 2/6

Grammar of the English Tongue,
Spoken and Written. With an Introduction to the Study of Comparative Philology. By HYDE CLARKE, D.C.L. Fifth Edition. . . . 1/6

Dictionary of the English Language.
As Spoken and Written. Containing above 100,000 Words. By HYDE CLARKE, D.C.L. 3/6
Complete with the GRAMMAR, 5/6

Composition and Punctuation,
Familiarly Explained for those who have neglected the Study of Grammar. By JUSTIN BRENAN. 18th Edition. 1/6

French Grammar.
With Complete and Concise Rules on the Genders of French Nouns. By G. L. STRAUSS, Ph.D. 1/6

English-French Dictionary.
Comprising a large number of Terms used in Engineering, Mining, &c. By ALFRED ELWES 2/0

French Dictionary.
In two Parts—I. French-English. II. English-French, complete in One Vol. 3/0
*** *Or with the* GRAMMAR, 4/6.

French and English Phrase Book.
Containing Introductory Lessons, with Translations, Vocabularies of Words, Collection of Phrases, and Easy Familiar Dialogues 1/6

German Grammar.
Adapted for English Students, from Heyse's Theoretical and Practical Grammar, by Dr. G. L. STRAUSS 1/6

German Triglot Dictionary.
By N. E. S. A. HAMILTON. Part I. German-French-English. Part II. English-German-French. Part III. French-German-English . . 3/0

German Triglot Dictionary.
(As above). Together with German Grammar, in One Volume . 5/0

Italian Grammar.
Arranged in Twenty Lessons, with Exercises. By ALFRED ELWES. 1/6

Italian Triglot Dictionary,
Wherein the Genders of all the Italian and French Nouns are carefully noted down. By ALFRED ELWES. Vol. I. Italian-English-French. 2/6

Italian Triglot Dictionary.
By ALFRED ELWES. Vol. II. English-French-Italian . . . 2/6

Italian Triglot Dictionary.
By ALFRED ELWES. Vol. III. French-Italian-English . . . 2/6

Italian Triglot Dictionary.
(As above). In One Vol. 7/6

Spanish Grammar.
In a Simple and Practical Form. With Exercises. By ALFRED ELWES 1/6

Spanish-English and English-Spanish Dictionary.
Including a large number of Technical Terms used in Mining, Engineering, &c., with the proper Accents and the Gender of every Noun. By ALFRED ELWES 4/0
*** *Or with the* GRAMMAR, 6/0.

Portuguese Grammar,
In a Simple and Practical Form. With Exercises. By ALFRED ELWES 1/6

Portuguese-English and English-Portuguese Dictionary.
Including a large number of Technical Terms used in Mining, Engineering, &c., with the proper Accents and the Gender of every Noun. By ALFRED ELWES. Third Edition, revised 5/0
*** *Or with the* GRAMMAR, 7/0.

Animal Physics,
Handbook of. By DIONYSIUS LARDNER, D.C.L. With 520 Illustrations. In One Vol. (730 pages), cloth boards 7/6
*** *Sold also in Two Parts, as follows:—*
ANIMAL PHYSICS. By Dr. LARDNER. Part I., Chapters I.—VII. 4/0
ANIMAL PHYSICS. By Dr. LARDNER. Part II., Chapters VIII.—XVIII. 3/0

BRADBURY, AGNEW & CO., LD., PRINTERS, LONDON AND TONBRIDGE

7, STATIONERS' HALL COURT, LONDON, E.C.

CROSBY LOCKWOOD & SON'S

Catalogue of

Scientific, Technical and Industrial Books.

	PAGE		PAGE
MECHANICAL ENGINEERING	1	DECORATIVE ARTS	30
CIVIL ENGINEERING	10	NATURAL SCIENCE	32
MARINE ENGINEERING, &c.	17	CHEMICAL MANUFACTURES	34
MINING & METALLURGY	19	INDUSTRIAL ARTS	36
ELECTRICITY	23	COMMERCE, TABLES, &c.	41
ARCHITECTURE & BUILDING	25	AGRICULTURE & GARDENING	43
SANITATION & WATER SUPPLY	27	AUCTIONEERING, VALUING, &c.	46
CARPENTRY & TIMBER	28	LAW & MISCELLANEOUS	47

MECHANICAL ENGINEERING, &c.

THE MECHANICAL ENGINEER'S POCKET-BOOK.

Comprising Tables, Formulæ, Rules, and Data: A Handy Book of Reference for Daily Use in Engineering Practice. By D. KINNEAR CLARK, M. Inst. C.E. Fourth Edition. Small 8vo, 700 pp., bound in flexible Leather Cover, rounded corners **6/0**

SUMMARY OF CONTENTS:—MATHEMATICAL TABLES.—MEASUREMENT OF SURFACES AND SOLIDS.—ENGLISH AND FOREIGN WEIGHTS AND MEASURES.—MONEYS.—SPECIFIC GRAVITY, WEIGHT, AND VOLUME.—MANUFACTURED METALS.—STEEL PIPES.—BOLTS AND NUTS.—SUNDRY ARTICLES IN WROUGHT AND CAST IRON, COPPER, BRASS, LEAD, TIN, ZINC.—STRENGTH OF TIMBER.—STRENGTH OF CAST IRON.—STRENGTH OF WROUGHT IRON.—STRENGTH OF STEEL.—TENSILE STRENGTH OF COPPER, LEAD, &c.—RESISTANCE OF STONES AND OTHER BUILDING MATERIALS.—RIVETED JOINTS IN BOILER PLATES.—BOILER SHELLS.—WIRE ROPES AND HEMP ROPES.—CHAINS AND CHAIN CABLES.—FRAMING.—HARDNESS OF METALS, ALLOYS, AND STONES.—LABOUR OF ANIMALS.—MECHANICAL PRINCIPLES.—GRAVITY AND FALL OF BODIES.—ACCELERATING AND RETARDING FORCES.—MILL GEARING, SHAFTING, &c.—TRANSMISSION OF MOTIVE POWER.—HEAT.—COMBUSTION: FUELS.—WARMING, VENTILATION, COOKING STOVES.—STEAM.—STEAM ENGINES AND BOILERS.—RAILWAYS.—TRAMWAYS.—STEAM SHIPS.—PUMPING STEAM ENGINES AND PUMPS.—COAL GAS, GAS ENGINES, &c.—AIR IN MOTION.—COMPRESSED AIR.—HOT AIR ENGINES.—WATER POWER.—SPEED OF CUTTING TOOLS.—COLOURS.—ELECTRICAL ENGINEERING.

"Mr. Clark manifests what is an innate perception of what is likely to be useful in a pocket-book, and he is really unrivalled in the art of condensation. It is very difficult to hit upon any mechanical engineering subject concerning which this work supplies no information, and the excellent index at the end adds to its utility. In one word, it is an exceedingly handy and efficient tool, possessed of which the engineer will be saved many a wearisome calculation, or yet more wearisome hunt through various text-books and treatises, and, as such, we can heartily recommend it to our readers."—*The Engineer.*

"It would be found difficult to compress more matter within a similar compass, or produce a book of 650 pages which should be more compact or convenient for pocket reference. . . . Will be appreciated by mechanical engineers of all classes."—*Practical Engineer.*

MR. HUTTON'S PRACTICAL HANDBOOKS.

THE WORKS' MANAGER'S HANDBOOK.

Comprising Modern Rules, Tables, and Data. For Engineers, Millwrights, and Boiler Makers; Tool Makers, Machinists, and Metal Workers; Iron and Brass Founders, &c. By W. S. HUTTON, Civil and Mechanical Engineer, Author of "The Practical Engineer's Handbook." Fifth Edition, carefully Revised, with Additions. In One handsome Volume, medium 8vo, strongly bound 15/0

☞ *The Author having compiled Rules and Data for his own use in a great variety of modern engineering work, and having found his notes extremely useful, decided to publish them—revised to date—believing that a practical work, suited to the* DAILY REQUIREMENTS OF MODERN ENGINEERS, *would be favourably received.*

"Of this edition we may repeat the appreciative remarks we made upon the first and third. Since the appearance of the latter very considerable modifications have been made, although the total number of pages remains almost the same. It is a very useful collection of rules, tables, and workshop and drawing office data."—*The Engineer*, May 10, 1895.

"The author treats every subject from the point of view of one who has collected workshop notes for application in workshop practice, rather than from the theoretical or literary aspect. The volume contains a great deal of that kind of information which is gained only by practical experience, and is seldom written in books."—*The Engineer*, June 5, 1885.

"The volume is an exceedingly useful one, brimful with engineer's notes, memoranda, and rules, and well worthy of being on every mechanical engineer's bookshelf."—*Machinery World.*

"The information is precisely that likely to be required in practice. . . . The work forms a desirable addition to the library not only of the works' manager, but of any one connected with general engineering."—*Mining Journal.*

"Brimful of useful information, stated in a concise form. Mr. Hutton's books have met a pressing want among engineers. The book must prove extremely useful to every practical man possessing a copy."—*Practical Engineer.*

THE PRACTICAL ENGINEER'S HANDBOOK.

Comprising a Treatise on Modern Engines and Boilers, Marine, Locomotive, and Stationary. And containing a large collection of Rules and Practical Data relating to Recent Practice in Designing and Constructing all kinds of Engines, Boilers, and other Engineering work. The whole constituting a comprehensive Key to the Board of Trade and other Examinations for Certificates of Competency in Modern Mechanical Engineering. By WALTER S. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook for Engineers," &c. With upwards of 370 Illustrations. Fifth Edition, Revised with Additions. Medium 8vo, nearly 500 pp., strongly bound.

[Just Published. 18/0

☞ *This Work is designed as a companion to the Author's* "WORKS' MANAGER'S HANDBOOK." *It possesses many new and original features, and contains, like its predecessor, a quantity of matter not originally intended for publication, but collected by the Author for his own use in the construction of a great variety of* MODERN ENGINEERING WORK.

The information is given in a condensed and concise form, and is illustrated by upwards of 370 Woodcuts; and comprises a quantity of tabulated matter of great value to all engaged in designing, constructing, or estimating for ENGINES, BOILERS, *and* OTHER ENGINEERING WORK.

"We have kept it at hand for several weeks, referring to it as occasion arose, and we have not on a single occasion consulted its pages without finding the information of which we were in quest."—*Athenæum.*

"A thoroughly good practical handbook, which no engineer can go through without learning something that will be of service to him."—*Marine Engineer.*

"An excellent book of reference for engineers, and a valuable text-book for students of engineering."—*Scotsman.*

"This valuable manual embodies the results and experience of the leading authorities on mechanical engineering."—*Building News.*

"The author has collected together a surprising quantity of rules and practical data, and has shown much judgment in the selections he has made. . . . There is no doubt that this book is one of the most useful of its kind published, and will be a very popular compendium."—*Engineer.*

"A mass of information set down in simple language, and in such a form that it can be easily referred to at any time. The matter is uniformly good and well chosen, and is greatly elucidated by the illustrations. The book will find its way on to most engineers' shelves, where it will rank as one of the most useful books of reference."—*Practical Engineer.*

"Full of useful information, and should be found on the office shelf of all practical engineers."—*Mechanical Engineer.*

MR. HUTTON'S PRACTICAL HANDBOOKS—*continued.*

STEAM BOILER CONSTRUCTION.

A Practical Handbook for Engineers, Boiler-Makers, and Steam Users. Containing a large Collection of Rules and Data relating to Recent Practice in the Design, Construction, and Working of all Kinds of Stationary, Locomotive, and Marine Steam-Boilers. By WALTER S. HUTTON, Civil and Mechanical Engineer; Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. With upwards of 500 Illustrations. Third Edition, Revised and much Enlarged, medium 8vo, cloth . . **18/0**

☞ THIS WORK *is issued in continuation of the Series of Handbooks written by the Author, viz.:*—"THE WORKS' MANAGER'S HANDBOOK" *and* "THE PRACTICAL ENGINEER'S HANDBOOK," *which are so highly appreciated by engineers for the practical nature of their information; and is consequently written in the same style as those works.*

The Author believes that the concentration, in a convenient form for easy reference, of such a large amount of thoroughly practical information on Steam-Boilers, will be of considerable service to those for whom it is intended, and he trusts the book may be deemed worthy of as favourable a reception as has been accorded to its predecessors.

"One of the best, if not the best, books on boilers that has ever been published. The information is of the right kind, in a simple and accessible form. So far as generation is concerned, this is, undoubtedly, the standard book on steam practice."—*Electrical Review.*

"Every detail, both in boiler design and management, is clearly laid before the reader. The volume shows that boiler construction has been reduced to the condition of one of the most exact sciences; and such a book is of the utmost value to the *fin de siecle* Engineer and Works Manager."—*Marine Engineer.*

"There has long been room for a modern handbook on steam boilers; there is not that room now, because Mr. Hutton has filled it. It is a thoroughly practical book for those who are occupied in the construction, design, selection, or use of boilers."—*Engineer.*

"The book is of so important and comprehensive a character that it must find its way into the libraries of every one interested in boiler using or boiler manufacture if they wish to be thoroughly informed. We strongly recommend the book for the intrinsic value of its contents."—*Machinery Market.*

PRACTICAL MECHANICS' WORKSHOP COMPANION.

Comprising a great variety of the most useful Rules and Formulæ in Mechanical Science, with numerous Tables of Practical Data and Calculated Results for Facilitating Mechanical Operations. By WILLIAM TEMPLETON, Author of "The Engineer's Practical Assistant," &c., &c. Seventeenth Edition, Revised, Modernised, and considerably Enlarged by WALTER S. HUTTON, C.E., Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. Fcap. 8vo, nearly 500 pp., with 8 Plates and upwards of 250 Illustrative Diagrams, strongly bound for workshop or pocket wear and tear. **6/0**

"In its modernised form Hutton's 'Templeton' should have a wide sale, for it contains much valuable information which the mechanic will often find of use, and not a few tables and notes which he might look for in vain in other works. This modernised edition will be appreciated by all who have learned to value the original editions of 'Templeton."—*English Mechanic.*

"It has met with great success in the engineering workshop, as we can testify; and there are a great many men who, in a great measure, owe their rise in life to this little book."—*Building News.*

"This familiar text-book—well known to all mechanics and engineers—is of essential service to the every day requirements of engineers, millwrights, and the various trades connected with engineering and building. The new modernised edition is worth its weight in gold."—*Building News.* (Second Notice.)

"This well-known and largely-used book contains information, brought up to date, of the sort so useful to the foreman and draughtsman. So much fresh information has been introduced as to constitute it practically a new book. It will be largely used in the office and workshop."—*Mechanical World.*

"The publishers wisely entrusted the task of revision of this popular, valuable, and useful book to Mr. Hutton, than whom a more competent man they could not have found."—*Iron.*

ENGINEER'S AND MILLWRIGHT'S ASSISTANT.

A Collection of Useful Tables, Rules, and Data. By WILLIAM TEMPLETON. Seventh Edition, with Additions. 18mo, cloth **2/6**

"Occupies a foremost place among books of this kind. A more suitable present to an apprentice to any of the mechanical trades could not possibly be made."—*Building News.*

"A deservedly popular work. It should be in the 'drawer' of every mechanic."—*English Mechanic.*

THE MECHANICAL ENGINEER'S REFERENCE BOOK.

For Machine and Boiler Construction. In Two Parts. Part I. General Engineering Data. Part II. Boiler Construction. With 51 Plates and numerous Illustrations. By Nelson Foley, M.I.N.A. Second Edition, Revised throughout and much Enlarged. Folio, half-bound, net . £3 3s.

PART I.—Measures.—Circumferences and Areas, &c., Squares, Cubes, Fourth Powers.—Square and Cube Roots.—Surface of Tubes.—Reciprocals.—Logarithms.—Mensuration.—Specific Gravities and Weights.—Work and Power.—Heat.—Combustion.—Expansion and Contraction.—Expansion of Gases.—Steam.—Static Forces.—Gravitation and Attraction.—Motion and Computation of Resulting Forces.—Accumulated Work.—Centre and Radius of Gyration.—Moment of Inertia.—Centre of Oscillation.—Electricity.—Strength of Materials.—Elasticity.—Test Sheets of Metals.—Friction.—Transmission of Power.—Flow of Liquids.—Flow of Gases.—Air Pumps, Surface Condensers, &c.—Speed of Steamships.—Propellers.—Cutting Tools.—Flanges.—Copper Sheets and Tubes.—Screws, Nuts, Bolt Heads, &c.—Various Recipes and Miscellaneous Matter.—With Diagrams for Valve-Gear, Belting and Ropes, Discharge and Suction Pipes, Screw Propellers, and Copper Pipes.

PART II.—Treating of Power of Boilers.—Useful Ratios.—Notes on Construction.—Cylindrical Boiler Shells.—Circular Furnaces.—Flat Plates.—Stays.—Girders.—Screws.—Hydraulic Tests.—Riveting.—Boiler Setting, Chimneys, and Mountings.—Fuels, &c.—Examples of Boilers and Speeds of Steamships.—Nominal and Normal Horse Power.—With Diagrams for all Boiler Calculations and Drawings of many Varieties of Boilers.

"The book is one which every mechanical engineer may, with advantage to himself, add to his library."—*Industries.*

"Mr. Foley is well fitted to compile such a work. . . . The diagrams are a great feature of the work. . . . Regarding the whole work, it may be very fairly stated that Mr. Foley has produced a volume which will undoubtedly fulfil the desire of the author and become indispensable to all mechanical engineers."—*Marine Engineer.*

"We have carefully examined this work, and pronounce it a most excellent reference book for the use of marine engineers."—*Journal of American Society of Naval Engineers.*

COAL AND SPEED TABLES.

A Pocket Book for Engineers and Steam Users. By Nelson Foley, Author of "The Mechanical Engineer's Reference Book." Pocket-size, cloth . 3/6

"These tables are designed to meet the requirements of every-day use; are of sufficient scope for most practical purposes, and may be commended to engineers and users of steam."—*Iron.*

TEXT-BOOK ON THE STEAM ENGINE.

With a Supplement on Gas Engines, and Part II. on Heat Engines. By T. M. Goodeve, M.A., Barrister-at-Law, Professor of Mechanics at the Royal College of Science, London; Author of "The Principles of Mechanics," "The Elements of Mechanism," &c. Fourteenth Edition. Crown 8vo, cloth . 6/0

"Professor Goodeve has given us a treatise on the steam engine which will bear comparison with anything written by Huxley or Maxwell, and we can award it no higher praise."—*Engineer.*

"Mr. Goodeve's text-book is a work of which every young engineer should possess himself."—*Mining Journal.*

ON GAS ENGINES.

With Appendix describing a Recent Engine with Tube Igniter. By T. M. Goodeve, M.A. Crown 8vo, cloth 2/6

"Like all Mr. Goodeve's writings, the present is no exception in point of general excellence. It is a valuable little volume."—*Mechanical World.*

A TREATISE ON STEAM BOILERS.

Their Strength, Construction, and Economical Working. By R. Wilson, C.E. Fifth Edition. 12mo, cloth 6/0

"The best treatise that has ever been published on steam boilers.—*Engineer.*

"The author shows himself perfect master of his subject, and we heartily recommend all employing steam power to possess themselves of the work."—*Ryland's Iron Trade Circular.*

THE MECHANICAL ENGINEER'S COMPANION

of Areas, Circumferences, Decimal Equivalents, in inches and feet, millimetres, squares, cubes, roots, &c.; Weights, Measures, and other Data. Also Practical Rules for Modern Engine Proportions. By R. Edwards, M.Inst.C.E. Fcap. 8vo, cloth. [*Just Published.* 3/6

"A very useful little volume. It contains many tables, classified data and memoranda, generally useful to engineers."—*Engineer.*

"This small book is what it professes to be, viz.:—'a handy office companion,' giving as it does, in a succinct form, a variety of information likely to be required by mechanical engineers in their everyday office work."—*Nature.*

A HANDBOOK ON THE STEAM ENGINE.

With especial Reference to Small and Medium-sized Engines. For the Use of Engine Makers, Mechanical Draughtsmen, Engineering Students, and users of Steam Power. By HERMAN HAEDER, C.E. Translated from the German with considerable additions and alterations, by H. H. P. POWLES, A.M.I.C.E., M.I.M.E. Second Edition, Revised. With nearly 1,100 Illustrations. Crown 8vo, cloth **9/0**

"A perfect encyclopædia of the steam engine and its details, and one which must take a permanent place in English drawing-offices and workshops."—*A Foreman Pattern-maker.*

"This is an excellent book, and should be in the hands of all who are interested in the construction and design of medium-sized stationary engines. . . . A careful study of its contents and the arrangement of the sections leads to the conclusion that there is probably no other book like it in this country. The volume aims at showing the results of practical experience, and it certainly may claim a complete achievement of this idea."—*Nature.*

"There can be no question as to its value. We cordially commend it to all concerned in the design and construction of the steam engine."—*Mechanical World.*

BOILER AND FACTORY CHIMNEYS.

Their Draught-Power and Stability. With a chapter on *Lightning Conductors.* By ROBERT WILSON, A.I.C.E., Author of "A Treatise on Steam Boilers," &c. Crown 8vo, cloth **3/6**

"A valuable contribution to the literature of scientific building."—*The Builder.*

BOILER MAKER'S READY RECKONER & ASSISTANT.

With Examples of Practical Geometry and Templating, for the Use of Platers, Smiths, and Riveters. By JOHN COURTNEY, Edited by D. K. CLARK, M.I.C.E. Third Edition, 480 pp., with 140 Illustrations. Fcap. 8vo . **7/0**

"No workman or apprentice should be without this book."—*Iron Trade Circular.*

REFRIGERATING & ICE-MAKING MACHINERY.

A Descriptive Treatise for the Use of Persons Employing Refrigerating and Ice-Making Installations, and others. By A. J. WALLIS-TAYLER, A.-M. Inst. C.E. Second Edition, Revised and Enlarged. With Illustrations. Crown 8vo, cloth. [*Just Published.* **7/6**

"Practical, explicit, and profusely illustrated."—*Glasgow Herald.*

"We recommend the book, which gives the cost of various systems and illustrations showing details of parts of machinery and general arrangements of complete installations."—*Builder.*

"May be recommended as a useful description of the machinery, the processes, and of the facts, figures, and tabulated physics of refrigerating. It is one of the best compilations on the subject."—*Engineer.*

TEA MACHINERY AND TEA FACTORIES.

A Descriptive Treatise on the Mechanical Appliances required on Tea Plantations in the Preparation of Tea for the Market. By A. J. WALLIS-TAYLER, A.-M. Inst. C.E. With over 200 Illustrations. Medium 8vo, cloth. [*Nearly Ready. Price, about* **25/0**

ENGINEERING ESTIMATES, COSTS, AND ACCOUNTS.

A Guide to Commercial Engineering. With numerous examples of Estimates and Costs of Millwright Work, Miscellaneous Productions, Steam Engines and Steam Boilers; and a Section on the Preparation of Costs Accounts. By A GENERAL MANAGER. Second Edition. 8vo, cloth. [*Just Published.* **12/0**

"This is an excellent and very useful book, covering subject-matter in constant requisition in every factory and workshop. . . . The book is invaluable, not only to the young engineer, but also to the estimate department of every works."—*Builder.*

"We accord the work unqualified praise. The information is given in a plain, straightforward manner, and bears throughout evidence of the intimate practical acquaintance of the author with every phase of commercial engineering."—*Mechanical World.*

AERIAL OR WIRE-ROPE TRAMWAYS.

Their Construction and Management. By A. J. WALLIS-TAYLER, A.M.Inst.C.E. With 81 Illustrations. Crown 8vo, cloth. [*Just Published.* 7/6

"This is in its way an excellent volume. Without going into the minutiæ of the subject, it yet lays before its readers a very good exposition of the various systems of rope transmission in use, and gives as well not a little valuable information about their working, repair, and management. We can safely recommend it as a useful general treatise on the subject."—*The Engineer.*

"Mr. Tayler has treated the subject as concisely as thoroughness would permit. The book will rank with the best on this useful topic, and we recommend it to those whose business is the transporting of minerals and goods."—*Mining Journal.*

MOTOR CARS OR POWER-CARRIAGES FOR COMMON ROADS.

By A. J. WALLIS-TAYLER, Assoc. Memb. Inst. C.E., Author of "Modern Cycles," &c. 212 pp., with 76 Illustrations. Crown 8vo, cloth . . 4/6

"Mr. Wallis-Tayler's book is a welcome addition to the literature of the subject, as it is the production of an Engineer, and has not been written with a view to assist in the promotion of companies. . . . The book is clearly expressed throughout, and is just the sort of work that an engineer, thinking of turning his attention to motor-carriage work, would do well to read as a preliminary to starting operations."—*Engineering.*

PLATING AND BOILER MAKING.

A Practical Handbook for Workshop Operations. By JOSEPH G. HORNER, A.M.I.M.E. 380 pp. with 328 Illustrations. Crown 8vo, cloth . . 7/6

"The latest production from the pen of this writer is characterised by that evidence of close acquaintance with workshop methods which will render the book exceedingly acceptable to the practical hand. We have no hesitation in commending the work as a serviceable and practical handbook on a subject which has not hitherto received much attention from those qualified to deal with it in a satisfactory manner."—*Mechanical World.*

PATTERN MAKING.

A Practical Treatise, embracing the Main Types of Engineering Construction, and including Gearing, both Hand and Machine-made, Engine Work, Sheaves and Pulleys, Pipes and Columns, Screws, Machine Parts, Pumps and Cocks, the Moulding of Patterns in Loam and Greensand, &c., together with the methods of estimating the weight of Castings; with an Appendix of Tables for Workshop Reference. By JOSEPH G. HORNER, A.M.I.M.E. Second Edition, Enlarged. With 450 Illustrations. Crown 8vo, cloth 7/6

"A well-written technical guide, evidently written by a man who understands and has practised what he has written about. . . . We cordially recommend it to engineering students, young journeymen, and others desirous of being initiated into the mysteries of pattern-making."—*Builder.*

"More than 400 illustrations help to explain the text, which is, however, always clear and explicit, thus rendering the work an excellent *vade mecum* for the apprentice who desires to become master of his trade."—*English Mechanic.*

MECHANICAL ENGINEERING TERMS

(Lockwood's Dictionary of). Embracing those current in the Drawing Office, Pattern Shop, Foundry, Fitting, Turning, Smiths', and Boiler Shops, &c., &c. Comprising upwards of 6,000 Definitions. Edited by JOSEPH G. HORNER, A.M.I.M.E. Second Edition, Revised, with Additions. Crown 8vo, cloth 7/6

"Just the sort of handy dictionary required by the various trades engaged in mechanical engineering. The practical engineering pupil will find the book of great value in his studies, and every foreman engineer and mechanic should have a copy."—*Building News.*

"Not merely a dictionary, but, to a certain extent, also a most valuable guide. It strikes us as a happy idea to combine with a definition of the phrase useful information on the subject of which it treats."—*Machinery Market.*

TOOTHED GEARING.

A Practical Handbook for Offices and Workshops. By JOSEPH HORNER, A.M.I.M.E. With 184 Illustrations. Crown 8vo, cloth . . . 6/0

"We must give the book our unqualified praise for its thoroughness of treatment, and we can heartily recommend it to all interested as the most practical book on the subject yet written."—*Mechanical World.*

FIRES, FIRE-ENGINES, AND FIRE BRIGADES.

With a History of Fire-Engines, their Construction, Use, and Management; Foreign Fire Systems; Hints on Fire-Brigades, &c. By CHARLES F. T. YOUNG, C.E. 8vo, cloth . . . . . £1 4s.

"To such of our readers as are interested in the subject of fires and fire apparatus we can most heartily commend this book."—*Engineering.*

STONE-WORKING MACHINERY.

A Manual dealing with the Rapid and Economical Conversion of Stone. With Hints on the Arrangement and Management of Stone Works. By M. Powis Bale, M.I.M.E. Second Edition, enlarged. With Illustrations. Crown 8vo, cloth. [*Just Published.* **9/0**

"The book should be in the hands of every mason or student of stonework."—*Colliery Guardian.*

"A capital handbook for all who manipulate stone for building or ornamental purposes."—*Machinery Market.*

PUMPS AND PUMPING.

A Handbook for Pump Users. Being Notes on Selection, Construction, and Management. By M. Powis Bale, M.I.M.E. Third Edition, Revised. Crown 8vo, cloth. [*Just Published.* **2/6**

"The matter is set forth as concisely as possible. In fact, condensation rather than diffuseness has been the author's aim throughout; yet he does not seem to have omitted anything likely to be of use."—*Journal of Gas Lighting.*

"Thoroughly practical and simply and clearly written."—*Glasgow Herald.*

MILLING MACHINES AND PROCESSES.

A Practical Treatise on Shaping Metals by Rotary Cutters. Including Information on Making and Grinding the Cutters. By Paul N. Hasluck, Author of "Lathe-Work." 352 pp. With upwards of 300 Engravings. Large crown 8vo, cloth **12/6**

"A new departure in engineering literature. . . . We can recommend this work to all interested in milling machines; it is what it professes to be—a practical treatise."—*Engineer.*

"A capital and reliable book which will no doubt be of considerable service both to those who are already acquainted with the process as well as to those who contemplate its adoption."—*Industries.*

LATHE-WORK.

A Practical Treatise on the Tools, Appliances, and Processes employed in the Art of Turning. By Paul N. Hasluck. Sixth Edition. Crown 8vo, cloth **5/0**

"Written by a man who knows not only how work ought to be done, but who also knows how to do it, and how to convey his knowledge to others. To all turners this book would be valuable."—*Engineering.*

"We can safely recommend the work to young engineers. To the amateur it will simply be invaluable. To the student it will convey a great deal of useful information."—*Engineer.*

SCREW-THREADS,

And Methods of Producing Them. With numerous Tables and complete Directions for using Screw-Cutting Lathes. By Paul N. Hasluck, Author of "Lathe-Work," &c. With Seventy-four Illustrations. Fourth Edition, Re-written and Enlarged. Waistcoat-pocket size **1/6**

"Full of useful information, hints and practical criticism. Taps, dies, and screwing tools generally are illustrated and their actions described."—*Mechanical World.*

"It is a complete compendium of all the details of the screw-cutting lathe; in fact a *multum-in-parvo* on all the subjects it treats upon."—*Carpenter and Builder.*

TABLES AND MEMORANDA FOR ENGINEERS, MECHANICS, ARCHITECTS, BUILDERS, &c.

Selected and Arranged by Francis Smith. Sixth Edition, Revised, including Electrical Tables, Formulæ, and Memoranda. Waistcoat-pocket size, limp leather. [*Just Published.* **1/6**

"It would, perhaps, be as difficult to make a small pocket-book selection of notes and formulæ to suit ALL engineers as it would be to make a universal medicine; but Mr. Smith's waistcoat-pocket collection may be looked upon as a successful attempt."—*Engineer.*

"The best example we have ever seen of 270 pages of useful matter packed into the dimensions of a card case."—*Building News.* "A veritable pocket treasury of knowledge."—*Iron.*

POCKET GLOSSARY OF TECHNICAL TERMS.

English-French, French-English; with Tables suitable for the Architectural, Engineering, Manufacturing, and Nautical Professions. By John James Fletcher, Engineer and Surveyor. Second Edition, Revised and Enlarged, 200 pp. Waistcoat-pocket size, limp leather **1/6**

"It is a very great advantage for readers and correspondents in France and England to have so large a number of the words relating to engineering and manufacturers collected in a lilliputian volume. The little book will be useful both to students and travellers."—*Architect.*

"The glossary of terms is very complete, and many of the Tables are new and well arranged. We cordially commend the book."—*Mechanical World.*

THE ENGINEER'S YEAR BOOK FOR 1900.

Comprising Formulæ, Rules, Tables, Data and Memoranda in Civil, Mechanical, Electrical, Marine and Mine Engineering. By H. R. KEMPE, A.M. Inst. C.E., M.I.E.E., Technical Officer of the Engineer-in-Chief's Office, General Post Office, London, Author of "A Handbook of Electrical Testing." "The Electrical Engineer's Pocket-Book," &c. With about 1,000 Illustrations, specially Engraved for the work. Crown 8vo, 800 pp., leather. [*Just Published.* 8/0

"Represents an enormous quantity of work, and forms a desirable book of reference."—*The Engineer.*

"The volume is distinctly in advance of most similar publications in this country."—*Engineering.*

"This valuable and well-designed book of reference meets the demands of all descriptions of engineers."—*Saturday Review.*

"Teems with up-to-date information in every branch of engineering and construction,"—*Building News.*

"The needs of the engineering profession could hardly be supplied in a more admirable, complete and convenient form. To say that it more than sustains all comparisons is praise of the highest sort, and that may justly be said of it."—*Mining Journal.*

"There is certainly room for the newcomer, which supplies explanations and directions, as well as formulæ and tables. It deserves to become one of the most successful of the technical annuals."—*Architect.*

"Brings together with great skill all the technical information which an engineer has to use day by day. It is in every way admirably equipped, and is sure to prove successful."—*Scotsman.*

"The up-to-dateness of Mr. Kempe's compilation is a quality that will not be lost on the busy people for whom the work is intended."—*Glasgow Herald.*

THE PORTABLE ENGINE.

A Practical Manual on its Construction and Management. For the use of Owners and Users of Steam Engines generally. By WILLIAM DYSON WANSBROUGH. Crown 8vo, cloth 3/6

"This is a work of value to those who use steam machinery. . . . Should be read by every one who has a steam engine, on a farm or elsewhere."—*Mark Lane Express.*

"We cordially commend this work to buyers and owners of steam-engines, and to those who have to do with their construction or use."—*Timber Trades Journal.*

"Such a general knowledge of the steam-engine as Mr. Wansbrough furnishes to the reader should be acquired by all intelligent owners and others who use the steam-engine."—*Building News.*

"An excellent text-book of this useful form of engine. The 'Hints to Purchasers' contain a good deal of common-sense and practical wisdom."—*English Mechanic.*

IRON AND STEEL.

A Work for the Forge, Foundry, Factory, and Office. Containing ready, useful, and trustworthy Information for Ironmasters and their Stock-takers; Managers of Bar, Rail, Plate, and Sheet Rolling Mills; Iron and Metal Founders; Iron Ship and Bridge Builders: Mechanical, Mining, and Consulting Engineers; Architects, Contractors, Builders, &c. By CHARLES HOARE, Author of "The Slide Rule," &c. Ninth Edition. 32mo, leather . 6/0

"For comprehensiveness the book has not its equal."—*Iron.*

"One of the best of the pocket books."—*English Mechanic.*

CONDENSED MECHANICS.

A Selection of Formulæ, Rules, Tables, and Data for the Use of Engineering Students, Science Classes, &c. In accordance with the Requirements of the Science and Art Department. By W. G. CRAWFORD HUGHES, A.M.I.C.E. Crown 8vo, cloth 2/6

"The book is well fitted for those who are either confronted with practical problems in their work, or are preparing for examination and wish to refresh their knowledge by going through their formulæ again."—*Marine Engineer.*

"It is well arranged, and meets the wants of those for whom it is intended."—*Railway News.*

THE SAFE USE OF STEAM.

Containing Rules for Unprofessional Steam Users. By an ENGINEER. Seventh Edition. Sewed . . . . . 6d.

"If steam-users would but learn this little book by heart, boiler explosions would become sensations by their rarity."—*English Mechanic.*

HEATING BY HOT WATER.

With Information and Suggestions on the best Methods of Heating Public, Private and Horticultural Buildings. By WALTER JONES. Second Edition. With 96 Illustrations, crown 8vo, cloth . . . . . *Net* 2/6

"We confidently recommend all interested in heating by hot water to secure a copy of this valuable little treatise."—*The Plumber and Decorator.*

THE LOCOMOTIVE ENGINE.

The Autobiography of an Old Locomotive Engine. By ROBERT WEATHERBURN, M.I.M.E. With Illustrations and Portraits of GEORGE and ROBERT STEPHENSON. Crown 8vo, cloth. [*Just Published. Net* **2/6**

SUMMARY OF CONTENTS.—PROLOGUE.—CYLINDERS.—MOTIONS.—CONNECTING RODS.—FRAMES.—WHEELS.—PUMPS, CLACKS, &C.—INJECTORS.—BOILERS.—SMOKE BOX.—CHIMNEY.—WEATHER BOARD AND AWNING.—INTERNAL DISSENSIONS.—ENGINE DRIVERS, &C.

"It will be difficult to imagine anything more ingeniously planned, more cleverly worked out, and more charmingly written. Readers cannot fail to find the volume most enjoyable."—*The Herald.*

THE LOCOMOTIVE ENGINE AND ITS DEVELOPMENT.

A Popular Treatise on the Gradual Improvements made in Railway Engines between 1803 and 1890. By CLEMENT E. STRETTON, C.E. Fifth Edition, Enlarged. With 120 Illustrations. Crown 8vo, cloth. [*Just Published.* **3/6**

"Students of railway history and all who are interested in the evolution of the modern locomotive will find much to attract and entertain in this volume."—*The Times.*

LOCOMOTIVE ENGINE DRIVING.

A Practical Manual for Engineers in Charge of Locomotive Engines. By MICHAEL REYNOLDS, Member of the Society of Engineers, formerly Locomotive Inspector, L. B. & S. C. R. Ninth Edition. Including a KEY TO THE LOCOMOTIVE ENGINE. Crown 8vo, cloth **4/6**

"Mr. Reynolds has supplied a want, and has supplied it well. We can confidently recommend the book not only to the practical driver, but to everyone who takes an interest in the performance of locomotive engines."—*The Engineer.*

"Mr. Reynolds has opened a new chapter in the literature of the day. His treatise is admirable."—*Athenæum.*

THE MODEL LOCOMOTIVE ENGINEER,

Fireman, and Engine-Boy. Comprising a Historical Notice of the Pioneer Locomotive Engines and their Inventors. By MICHAEL REYNOLDS. Second Edition, with Revised Appendix. Crown 8vo, cloth. [*Just Published.* **4/6**

"From the technical knowledge of the author, it will appeal to the railway man of to-day more forcibly than anything written by Dr. Smiles. . . . The volume contains information of a technical kind, and facts that every driver should be familiar with."—*English Mechanic.*

"We should be glad to see this book in the possession of everyone in the kingdom who has ever laid, or is to lay, hands on a locomotive engine."—*Iron.*

CONTINUOUS RAILWAY BRAKES.

A Practical Treatise on the several Systems in Use in the United Kingdom: their Construction and Performance. With copious Illustrations and numerous Tables. By MICHAEL REYNOLDS. 8vo, cloth **9/0**

"A popular explanation of the different brakes. It will be of great assistance in forming public opinion, and will be studied with benefit by those who take an interest in the brake."—*English Mechanic.*

STATIONARY ENGINE DRIVING.

A Practical Manual for Engineers in Charge of Stationary Engines. By MICHAEL REYNOLDS. Fifth Edition. Crown 8vo, cloth **4/6**

"The author is thoroughly acquainted with his subjects, and his advice on the various points treated is clear and practical. . . . He has produced a manual which is an exceedingly useful one for the class for whom it is specially intended."—*Engineering.*

"Our author leaves no stone unturned. He is determined that his readers shall not only know something about the stationary engine, but all about it."—*Engineer.*

ENGINE-DRIVING LIFE.

Stirring Adventures and Incidents in the Lives of Locomotive Engine-Drivers. By MICHAEL REYNOLDS. Third Edition. Crown 8vo, cloth . **1/6**

"Perfectly fascinating. Wilkie Collins's most thrilling conceptions are thrown into the shade by true incidents, endless in their variety, related in every page."—*North British Mail.*

THE ENGINEMAN'S POCKET COMPANION,

And Practical Educator for Enginemen, Boiler Attendants, and Mechanics By MICHAEL REYNOLDS. With 45 Illustrations and numerous Diagrams. Third Edition, Revised. Royal 18mo, strongly bound for pocket wear . **3/6**

"This admirable work is well suited to accomplish its object, being the honest workmanship of a competent engineer."—*Glasgow Herald.*

CIVIL ENGINEERING, SURVEYING, &c.

LIGHT RAILWAYS FOR THE UNITED KINGDOM, INDIA, AND THE COLONIES.

A Practical Handbook setting forth the Principles on which Light Railways should be Constructed, Worked, and Financed; and detailing the Cost of Construction, Equipment, Revenue and Working Expenses of Local Railways already established in the above-mentioned countries, and in Belgium, France, Switzerland, &c. By J. C. MACKAY, F.G.S., A.M. Inst. C.E. Illustrated with Plates and Diagrams. Medium 8vo, cloth. [*Just Published.* 15/0

"Mr. Mackay's volume is clearly and concisely written, admirably arranged, and freely illustrated. The book is exactly what has been long wanted. We recommend it to all interested in the subject. It is sure to have a wide sale."—*Railway News.*

"Those who desire to have within reach general information concerning almost all the light railway systems in the world will do well to buy Mr. Mackay's book."—*Engineer.*

"This work appears very opportunely, when the extension of the system on a large scale to England is at last being mooted. In its pages we find all the information that the heart of man can desire on the subject. . . . every detail in its story, founded on the experience of other countries and applied to the possibilities of England, is put before us."—*Spectator.*

PRACTICAL TUNNELLING.

Explaining in detail Setting-out the Works, Shaft-sinking, and Heading-driving, Ranging the Lines and Levelling underground, Sub-Excavating, Timbering and the Construction of the Brickwork of Tunnels, with the amount of Labour required for, and the Cost of, the various portions of the work. By FREDERICK W. SIMMS, M. Inst. C.E. Fourth Edition, Revised and Further Extended, including the most recent (1895) Examples of Sub-aqueous and other Tunnels, by D. KINNEAR CLARK, M. Inst. C.E. Imperial 8vo, with 34 Folding Plates and other Illustrations. Cloth. [*Just Published.* £2 2s.

"The present (1896) edition has been brought right up to date, and is thus rendered a work to which civil engineers generally should have ready access, and to which engineers who have construction work can hardly afford to be without, but which to the younger members of the profession is invaluable, as from its pages they can learn the state to which the science of tunnelling has attained."—*Railway News.*

"The estimation in which Mr. Simms's book has been held for many years cannot be more truly expressed than in the words of the late Prof. Rankine: 'The best source of information on the subject of tunnels is Mr. F. W. Simms's work on Practical Tunnelling.'"—*Architect.*

THE WATER SUPPLY OF TOWNS AND THE CONSTRUCTION OF WATER-WORKS.

A Practical Treatise for the Use of Engineers and Students of Engineering. By W. K. BURTON, A.M. Inst. C.E., Professor of Sanitary Engineering in the Imperial University, Tokyo, Japan, and Consulting Engineer to the Tokyo Water-works. Second Edition, Revised and Extended. With numerous Plates and Illustrations. Super-royal 8vo, buckram. [*Just Published.* 25/0

I. INTRODUCTORY.—II. DIFFERENT QUALITIES OF WATER.—III. QUANTITY OF WATER TO BE PROVIDED.—IV. ON ASCERTAINING WHETHER A PROPOSED SOURCE OF SUPPLY IS SUFFICIENT.—V. ON ESTIMATING THE STORAGE CAPACITY REQUIRED TO BE PROVIDED.—VI. CLASSIFICATION OF WATER-WORKS.—VII. IMPOUNDING RESERVOIRS.—VIII. EARTHWORK DAMS.—IX. MASONRY DAMS.—X. THE PURIFICATION OF WATER.—XI. SETTLING RESERVOIRS.—XII. SAND FILTRATION.—XIII. PURIFICATION OF WATER BY ACTION OF IRON, SOFTENING OF WATER BY ACTION OF LIME, NATURAL FILTRATION.—XIV. SERVICE OR CLEAN WATER RESERVOIRS—WATER TOWERS—STAND PIPES.—XV. THE CONNECTION OF SETTLING RESERVOIRS, FILTER BEDS AND SERVICE RESERVOIRS.—XVI. PUMPING MACHINERY.—XVII. FLOW OF WATER IN CONDUITS—PIPES AND OPEN CHANNELS.—XVIII. DISTRIBUTION SYSTEMS.—XIX. SPECIAL PROVISIONS FOR THE EXTINCTION OF FIRE.—XX. PIPES FOR WATER-WORKS.—XXI. PREVENTION OF WASTE OF WATER.—XXII. VARIOUS APPLICATIONS USED IN CONNECTION WITH WATER-WORKS.

APPENDIX I. By PROF. JOHN MILNE, F.R.S.—CONSIDERATIONS CONCERNING THE PROBABLE EFFECTS OF EARTHQUAKES ON WATER-WORKS, AND THE SPECIAL PRECAUTIONS TO BE TAKEN IN EARTHQUAKE COUNTRIES.

APPENDIX II. By JOHN DE RIJKE, C.E.—ON SAND DUNES AND DUNE SAND AS A SOURCE OF WATER SUPPLY.

"The chapter upon filtration of water is very complete, and the details of construction well illustrated. . . . The work should be specially valuable to civil engineers engaged in work in Japan, but the interest is by no means confined to that locality."—*Engineer.*

"We congratulate the author upon the practical commonsense shown in the preparation of this work. . . . The plates and diagrams have evidently been prepared with great care, and cannot fail to be of great assistance to the student."—*Builder.*

"The whole art of water-works construction is dealt with in a clear and comprehensive fashion in this handsome volume. . . . Mr. Burton's practical treatise shows in all its sections the fruit of independent study and individual experience. It is largely based upon his own practice in the branch of engineering of which it treats."—*Saturday Review.*

THE WATER SUPPLY OF CITIES AND TOWNS.

By WILLIAM HUMBER, A. M. Inst. C.E., and M. Inst. M.E., Author of "Cast and Wrought Iron Bridge Construction," &c., &c. Illustrated with 50 Double Plates, 1 Single Plate, Coloured Frontispiece, and upwards of 250 Woodcuts, and containing 400 pp. of Text. Imp. 4to, elegantly and substantially half-bound in morocco . . . . . *Net* **£6 6s.**

LIST OF CONTENTS.

I. HISTORICAL SKETCH OF SOME OF THE MEANS THAT HAVE BEEN ADOPTED FOR THE SUPPLY OF WATER TO CITIES AND TOWNS.—II. WATER AND THE FOREIGN MATTER USUALLY ASSOCIATED WITH IT.—III. RAINFALL AND EVAPORATION.—IV. SPRINGS AND THE WATER-BEARING FORMATIONS OF VARIOUS DISTRICTS.—V. MEASUREMENT AND ESTIMATION OF THE FLOW OF WATER.—VI. ON THE SELECTION OF THE SOURCE OF SUPPLY.—VII. WELLS.—VIII. RESERVOIRS.—IX. THE PURIFICATION OF WATER.—X. PUMPS.—XI. PUMPING MACHINERY.—XII. CONDUITS.—XIII. DISTRIBUTION OF WATER.—XIV. METERS, SERVICE PIPES, AND HOUSE FITTINGS.—XV. THE LAW OF ECONOMY OF WATER-WORKS.—XVI. CONSTANT AND INTERMITTENT SUPPLY.—XVII. DESCRIPTION OF PLATES.—APPENDICES, GIVING TABLES OF RATES OF SUPPLY, VELOCITIES, &c., &c., TOGETHER WITH SPECIFICATIONS OF SEVERAL WORKS ILLUSTRATED, AMONG WHICH WILL BE FOUND ABERDEEN, BIDEFORD, CANTERBURY, DUNDEE, HALIFAX, LAMBETH, ROTHERHAM, DUBLIN, AND OTHERS.

"The most systematic and valuable work upon water supply hitherto produced in English, or in any other language. . . . Mr. Humber's work is characterised almost throughout by an exhaustiveness much more distinctive of French and German than of English technical treatises."—*Engineer.*

RURAL WATER SUPPLY.

A Practical Handbook on the Supply of Water and Construction of Water-works for small Country Districts. By ALLAN GREENWELL, A.M.I.C.E., and W. T. CURRY, A.M.I.C.E., F.G.S. With Illustrations. Second Edition, Revised. Crown 8vo, cloth. [*Just Published.* **5/0**

"We conscientiously recommend it as a very useful book for those concerned in obtaining water for small districts, giving a great deal of practical information in a small compass."—*Builder.*

"The volume contains valuable information upon all matters connected with water supply. . . . It is full of details on points which are continually before water-works engineers."—*Nature.*

HYDRAULIC POWER ENGINEERING.

A Practical Manual on the Concentration and Transmission of Power by Hydraulic Machinery. By G. CROYDON MARKS, A.M. Inst. C.E. With nearly 200 Illustrations. 8vo, cloth. [*Just Published.* *Net* **9 0**

SUMMARY OF CONTENTS.—PRINCIPLES OF HYDRAULICS.—THE OBSERVED FLOW OF WATER.—HYDRAULIC PRESSURES, MATERIAL.—TEST LOAD PACKINGS FOR SLIDING SURFACES.—PIPE JOINTS.—CONTROLLING VALVES.—PLATFORM LIFTS.—WORKSHOP, FACTORY, AND DOCK CRANES.—HYDRAULIC ACCUMULATORS.—PRESSES.—SHEET METAL WORKING AND FORGING MACHINERY.—HYDRAULIC RIVETERS.—HAND, POWER, AND STEAM PUMPS.—TURBINES.—IMPULSE AND REACTION TURBINES.—DESIGN OF TURBINES.—WATER WHEELS.—HYDRAULIC ENGINES.—RECENT ACHIEVEMENTS.—APPENDIX OF TABLES.

HYDRAULIC TABLES, CO-EFFICIENTS, & FORMULÆ.

For Finding the Discharge of Water from Orifices, Notches, Weirs, Pipes, and Rivers. With New Formulæ, Tables, and General Information on Rain-fall, Catchment-Basins, Drainage, Sewerage, Water Supply for Towns and Mill Power. By JOHN NEVILLE, Civil Engineer, M.R.I.A. Third Edition, revised, with additions. Numerous Illustrations. Crown 8vo, cloth . **14/0**

"It is, of all English books on the subject, the one nearest to completeness."—*Architect.*

HYDRAULIC MANUAL.

Consisting of Working Tables and Explanatory Text. Intended as a Guide in Hydraulic Calculations and Field Operations. By LOWIS D'A. JACKSON, Author of "Aid to Survey Practice," "Modern Metrology," &c. Fourth Edition, Enlarged. Large crown 8vo, cloth **16/0**

"The author has constructed a manual which may be accepted as a trustworthy guide to this branch of the engineer's profession."—*Engineering.*

WATER ENGINEERING.

A Practical Treatise on the Measurement, Storage, Conveyance, and Utilisation of Water for the Supply of Towns, for Mill Power, and for other Purposes. By C. SLAGG, A. M. Inst. C.E. Second Edition. Crown 8vo, cloth . **7/6**

"As a small practical treatise on the water supply of towns, and on some applications of water-power, the work is in many respects excellent."—*Engineering.*

EMBANKMENT AND RECLAMATION OF LAND.

A Practical Handbook for the use of Engineers. By ALEX. BRAZELEY, M. Inst. C.E. Crown 8vo, cloth. [*Just Published.* *Net* 7/6

MASONRY DAMS FROM INCEPTION TO COMPLETION.

Including numerous Formulæ, Forms of Specification and Tender, Pocket Diagram of Forces, &c. For the use of Civil and Mining Engineers. By C. F. COURTNEY, M. Inst. C.E. 8vo, cloth. [*Just Published.* 9/0

"The volume contains a good deal of valuable data, and furnishes the engineer with practical advice. The author deals with his subject from the inception to the finish. Many useful suggestions will be found in the remarks on site and position, location of dam, foundations and construction."—*Building News.*

RIVER BARS.

The Causes of their Formation, and their Treatment by "Induced Tidal Scour;" with a Description of the Successful Reduction by this Method of the Bar at Dublin. By I. J. MANN, Assist. Eng. to the Dublin Port and Docks Board. Royal 8vo, cloth 7/6

"We recommend all interested in harbour works—and, indeed, those concerned in the improvements of rivers generally—to read Mr. Mann's interesting work."—*Engineer.*

TRAMWAYS: THEIR CONSTRUCTION AND WORKING.

Embracing a Comprehensive History of the System; with an exhaustive Analysis of the Various Modes of Traction, including Horse Power, Steam, Cable Traction, Electric Traction, &c.; a Description of the Varieties of Rolling Stock; and ample Details of Cost and Working Expenses. New Edition, Thoroughly Revised, and Including the Progress recently made in Tramway Construction, &c., &c. By D. KINNEAR CLARK, M. Inst. C.E. With 400 Illustrations. 8vo, 720 pp., buckram. [*Just Published.* 28/0

"Although described as a new edition, this book is really a new one, a large part of it, which covers historical ground, having been re-written and amplified; while the parts which relate to all that has been done since 1882 appear in this edition only. It is sixteen years since the first edition appeared, and twelve years since the supplementary volume to the first book was published. After a lapse, then, of twelve years, it is obvious that the author has at his disposal a vast quantity of descriptive and statistical information, with which he may, and has, produced a volume of great value to all interested in tramway construction and working. The new volume is one which will rank, among tramway engineers and those interested in tramway working, with his world-famed book on railway machinery."—*The Engineer.*

PRACTICAL SURVEYING.

A Text-Book for Students preparing for Examinations or for Survey-work in the Colonies. By GEORGE W. USILL, A.M.I.C.E. With 4 Plates and upwards of 330 Illustrations. Sixth Edition. Including Tables of Natural Sines, Tangents, Secants, &c. Crown 8vo, cloth 7/6; or, on THIN PAPER, leather, gilt edges, for pocket use. [*Just Published.* 12/6

"The best forms of instruments are described as to their construction, uses and modes of employment, and there are innumerable hints on work and equipment such as the author, in his experience as surveyor, draughtsman and teacher, has found necessary, and which the student in his inexperience will find most serviceable."—*Engineer.*

"The latest treatise in the English language on surveying, and we have no hesitation in saying that the student will find it a better guide than any of its predecessors. Deserves to be recognised as the first book which should be put in the hands of a pupil of Civil Engineering."—*Architect.*

SURVEYING WITH THE TACHEOMETER.

A practical Manual for the use of Civil and Military Engineers and Surveyors. Including two series of Tables specially computed for the Reduction of Readings from Sexagesimal and from Centesimal Degrees. By NEIL KENNEDY, M. Inst. C.E. Demy 8vo, with Diagrams and Plates.

[*In the Press. Price, about* 10/6 *Net.*

AID TO SURVEY PRACTICE.

For Reference in Surveying, Levelling, and Setting-out; and in Route Surveys of Travellers by Land and Sea. With Tables, Illustrations, and Records. By LOWIS D'A. JACKSON, A.M.I.C.E. 8vo, cloth 12/6

"A valuable *vade-mecum* for the surveyor. We recommend this book as containing an admirable supplement to the teaching of the accomplished surveyor."—*Athenæum.*

"The author brings to his work a fortunate union of theory and practical experience which, aided by a clear and lucid style of writing, renders the book a very useful one."—*Builder.*

ENGINEER'S & MINING SURVEYOR'S FIELD BOOK.

Consisting of a Series of Tables, with Rules, Explanations of Systems, and use of Theodolite for Traverse Surveying and plotting the work with minute accuracy by means of Straight Edge and Set Square only; Levelling with the Theodolite, Casting-out and Reducing Levels to Datum, and Plotting Sections in the ordinary manner; Setting-out Curves with the Theodolite by Tangential Angles and Multiples with Right and Left-hand Readings of the Instrument; Setting-out Curves without Theodolite on the System of Tangential Angles by Sets of Tangents and Offsets; and Earthwork Tables to 80 feet deep, calculated for every 6 inches in depth. By W. DAVIS HASKOLL, C.E. With numerous Woodcuts. Fourth Edition, Enlarged. Crown 8vo, cloth . **12/0**

"The book is very handy: the separate tables of sines and tangents to every minute will make it useful for many other purposes, the genuine traverse tables existing all the same."—*Athenæum.*

"Every person engaged in engineering field operations will estimate the importance of such a work and the amount of valuable time which will be saved by reference to a set of reliable tables prepared with the accuracy and fulness of those given in this volume."—*Railway News.*

LAND AND MARINE SURVEYING.

In Reference to the Preparation of Plans for Roads and Railways; Canals, Rivers, Towns' Water Supplies; Docks and Harbours. With Description and Use of Surveying Instruments. By W. DAVIS HASKOLL, C.E. Second Edition, Revised, with Additions. Large crown 8vo, cloth . . . **9/0**

"This book must prove of great value to the student. We have no hesitation in recommending it, feeling assured that it will more than repay a careful study."—*Mechanical World.*

"A most useful book for the student. We strongly recommend it as a carefully-written and valuable text-book. It enjoys a well-deserved repute among surveyors."—*Builder.*

"This volume cannot fail to prove of the utmost practical utility. It may be safely recommended to all students who aspire to become clean and expert surveyors."—*Mining Journal.*

PRINCIPLES AND PRACTICE OF LEVELLING.

Showing its Application to Purposes of Railway and Civil Engineering in the Construction of Roads; with Mr. TELFORD'S Rules for the same. By FREDERICK W. SIMMS, F.G.S., M. Inst. C.E. Eighth Edition, with the addition of LAW'S Practical Examples for Setting-out Railway Curves, and TRAUTWINE'S Field Practice of Laying-out Circular Curves. With 7 Plates and numerous Woodcuts, 8vo, cloth **8/6**

*** TRAUTWINE on CURVES may be had separate **5/0**

"The text-book on levelling in most of our engineering schools and colleges."—*Engineer.*

"The publishers have rendered a substantial service to the profession, especially to the younger members, by bringing out the present edition of Mr. Simms's useful work."—*Engineering.*

AN OUTLINE OF THE METHOD OF CONDUCTING A TRIGONOMETRICAL SURVEY.

For the Formation of Geographical and Topographical Maps and Plans, Military Reconnaissance, LEVELLING, &c., with Useful Problems, Formulæ, and Tables. By Lieut.-General FROME, R.E. Fourth Edition, Revised and partly Re-written by Major-General Sir CHARLES WARREN, G.C.M.G., R.E. With 19 Plates and 115 Woodcuts, royal 8vo, cloth **16/0**

"No words of praise from us can strengthen the position so well and so steadily maintained by this work. Sir Charles Warren has revised the entire work, and made such additions as were necessary to bring every portion of the contents up to the present date."—*Broad Arrow.*

TABLES OF TANGENTIAL ANGLES AND MULTIPLES FOR SETTING-OUT CURVES.

From 5 to 200 Radius. By A. BEAZELEY, M. Inst. C.E. 6th Edition, Revised. With an Appendix on the use of the Tables for Measuring up Curves. Printed on 50 Cards, and sold in a cloth box, waistcoat-pocket size. [*Just Published.* **3/6**

"Each table is printed on a card, which, placed on the theodolite, leaves the hands free to manipulate the instrument—no small advantage as regards the rapidity of work."—*Engineer.*

"Very handy: a man may know that all his day's work must fall on two of these cards, which he puts into his own card-case, and leaves the rest behind."—*Athenæum.*

HANDY GENERAL EARTH-WORK TABLES.

Giving the Contents in Cubic Yards of Centre and Slopes of Cuttings and Embankments from 3 inches to 80 feet in Depth or Height, for use with either 66 feet Chain or 100 feet Chain. By J. H. WATSON BUCK, M. Inst. C.E. On a Sheet mounted in cloth case. [*Just Published* **3/6**

EARTHWORK TABLES.

Showing the Contents in Cubic Yards of Embankments, Cuttings, &c., of Heights or Depths up to an average of 80 feet. By JOSEPH BROADBENT, C.E., and FRANCIS CAMPIN, C.E. Crown 8vo, cloth 5/0

"The way in which accuracy is attained, by a simple division of each cross section into three elements, two in which are constant and one variable, is ingenious."—*Athenæum.*

A MANUAL ON EARTHWORK.

By ALEX. J. S. GRAHAM, C.E. With numerous Diagrams. Second Edition. 18mo, cloth 2/6

THE CONSTRUCTION OF LARGE TUNNEL SHAFTS.

A Practical and Theoretical Essay. By J. H. WATSON BUCK, M. Inst. C.E., Resident Engineer, L. and N. W. R. With Folding Plates, 8vo, cloth 12/0

"Many of the methods given are of extreme practical value to the mason, and the observations on the form of arch, the rules for ordering the stone, and the construction of the templates, will be found of considerable use. We commend the book to the engineering profession."—*Building News.*

"Will be regarded by civil engineers as of the utmost value, and calculated to save much time and obviate many mistakes."—*Colliery Guardian.*

CAST & WROUGHT IRON BRIDGE CONSTRUCTION

(A Complete and Practical Treatise on), including Iron Foundations. In Three Parts.—Theoretical, Practical, and Descriptive. By WILLIAM HUMBER, A. M. Inst. C.E., and M. Inst. M.E. Third Edition, revised and much improved, with 115 Double Plates (20 of which now first appear in this edition), and numerous Additions to the Text. In 2 vols., imp. 4to, half-bound in morocco . . . . . £6 16s. 6d.

"A very valuable contribution to the standard literature of civil engineering. In addition to elevations, plans, and sections, large scale details are given, which very much enhance the instructive worth of those illustrations."—*Civil Engineer and Architect's Journal.*

"Mr. Humber's stately volumes, lately issued—in which the most important bridges erected during the last five years, under the direction of the late Mr Brunel, Sir W. Cubitt, Mr. Hawkshaw, Mr. Page, Mr. Fowler, Mr. Hemans, and others among our most eminent engineers, are drawn and specified in great detail."—*Engineer.*

ESSAY ON OBLIQUE BRIDGES

(Practical and Theoretical). With 13 large Plates. By the late GEORGE WATSON BUCK, M.I.C.E. Fourth Edition, revised by his Son, J. H. WATSON BUCK, M.I.C.E.: and with the addition of Description to Diagrams for Facilitating the Construction of Oblique Bridges, by W. H. BARLOW, M.I.C.E. Royal 8vo, cloth 12/0

"The standard text-book for all engineers regarding skew arches is Mr. Buck's treatise, and it would be impossible to consult a better."—*Engineer.*

"Mr. Buck's treatise is recognised as a standard text-book, and his treatment has divested the subject of many of the intricacies supposed to belong to it. As a guide to the engineer and architect, on a confessedly difficult subject, Mr. Buck's work is unsurpassed."—*Building News.*

THE CONSTRUCTION OF OBLIQUE ARCHES

(A Practical Treatise on). By JOHN HART. Third Edition, with Plates. Imperial 8vo, cloth 8/0

GRAPHIC AND ANALYTIC STATICS.

In their Practical Application to the Treatment of Stresses in Roofs, Solid Girders, Lattice, Bowstring, and Suspension Bridges, Braced Iron Arches and Piers, and other Frameworks. By R. HUDSON GRAHAM, C.E. Containing Diagrams and Plates to Scale. With numerous Examples, many taken from existing Structures. Specially arranged for Class-work in Colleges and Universities. Second Edition, Revised and Enlarged. 8vo, cloth . 16/0

"Mr. Graham's book will find a place wherever graphic and analytic statics are used or studied."—*Engineer.*

"The work is excellent from a practical point of view, and has evidently been prepared with much care. The directions for working are simple, and are illustrated by an abundance of well-selected examples. It is an excellent text-book for the practical draughtsman."—*Athenæum.*

WEIGHTS OF WROUGHT IRON & STEEL GIRDERS.

A Graphic Table for Facilitating the Computation of the Weights of Wrought Iron and Steel Girders, &c., for Parliamentary and other Estimates. By J. H. WATSON BUCK, M. Inst. C.E. On a Sheet 2/6

PRACTICAL GEOMETRY.

For the Architect, Engineer, and Mechanic. Giving Rules for the Delineation and Application of various Geometrical Lines, Figures, and Curves. By E. W. TARN, M.A., Architect. 8vo, cloth **9/0**

"No book with the same objects in view has ever been published in which the clearness of the rules laid down and the illustrative diagrams have been so satisfactory."—*Scotsman.*

THE GEOMETRY OF COMPASSES.

Or, Problems Resolved by the mere Description of Circles and the Use of Coloured Diagrams and Symbols. By OLIVER BYRNE. Coloured Plates. Crown 8vo, cloth **3/6**

HANDY BOOK FOR THE CALCULATION OF STRAINS

In Girders and Similar Structures and their Strength. Consisting of Formulæ and Corresponding Diagrams, with numerous details for Practical Application, &c. By WILLIAM HUMBER, A. M. Inst. C.E., &c. Fifth Edition. Crown 8vo, with nearly 100 Woodcuts and 3 Plates, cloth . . . **7/6**

"The formulæ are neatly expressed, and the diagrams good."—*Athenæum.*

"We heartily commend this really *handy* book to our engineer and architect readers."—*English Mechanic.*

TRUSSES OF WOOD AND IRON.

Practical Applications of Science in Determining the Stresses, Breaking Weights, Safe Loads, Scantlings, and Details of Construction. With Complete Working Drawings. By WILLIAM GRIFFITHS, Surveyor. 8vo, cloth. **4/6**

"This handy little book enters so minutely into every detail connected with the construction of roof trusses that no student need be ignorant of these matters."—*Practical Engineer.*

THE STRAINS ON STRUCTURES OF IRONWORK.

With Practical Remarks on Iron Construction. By F. W. SHEILDS, M.I.C.E. 8vo, cloth **5/0**

A TREATISE ON THE STRENGTH OF MATERIALS.

With Rules for Application in Architecture, the Construction of Suspension Bridges, Railways, &c. By PETER BARLOW, F.R.S. A new Edition, revised by his Sons, P. W. BARLOW, F.R.S., and W. H. BARLOW, F.R.S.; to which are added, Experiments by HODGKINSON, FAIRBAIRN, and KIRKALDY; and Formulæ for calculating Girders, &c. Arranged and Edited by WM. HUMBER, A. M. Inst. C.E. 8vo, cloth **18/0**

"Valuable alike to the student, tyro, and the experienced practitioner, it will always rank future as it has hitherto done, as the standard treatise on that particular subject."—*Engineer.*

"As a scientific work of the first class, it deserves a foremost place on the bookshelves of every civil engineer and practical mechanic."—*English Mechanic.*

STRENGTH OF CAST IRON AND OTHER METALS.

By THOMAS TREDGOLD, C.E. Fifth Edition, including HODGKINSON'S Experimental Researches. 8vo, cloth **12/0**

SAFE RAILWAY WORKING.

A Treatise on Railway Accidents, their Cause and Prevention; with a Description of Modern Appliances and Systems. By CLEMENT E. STRETTON, C.E., Vice-President and Consulting Engineer, Amalgamated Society of Railway Servants. With Illustrations and Coloured Plates. Third Edition, Enlarged. Crown 8vo, cloth **3/6**

"A book for the engineer, the directors, the managers, and, in short, all who wish for information on railway matters will find a perfect encyclopædia in 'Safe Railway Working.'"—*Railway Review.*

"We commend the remarks on railway signalling to all railway managers, especially where a uniform code and practice is advocated."—*Herepath's Railway Journal.*

EXPANSION OF STRUCTURES BY HEAT.

By JOHN KEILY, C.E., late of the Indian Public Works Department. Crown 8vo, cloth **3/6**

"The aim the author has set before him, viz., to show the effects of heat upon metallic and other structures, is a laudable one, for this is a branch of physics upon which the engineer or architect can find but little reliable and comprehensive data in books."—*Builder.*

THE PROGRESS OF MODERN ENGINEERING.

Complete in Four Volumes, imperial 4to, half-morocco, price £12 12s.
Each volume sold separately, as follows:—

FIRST SERIES, Comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, &c. By WILLIAM HUMBER, A. M. Inst. C.E., &c. Imp. 4to, with 36 Double Plates, drawn to a large scale, Photographic Portrait of John Hawkshaw, C.E., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c. Half-morocco . . . £3 3s.

LIST OF THE PLATES AND DIAGRAMS.

VICTORIA STATION AND ROOF, L. B. & S. C. R. (8 PLATES); SOUTHPORT PIER (4 PLATES); VICTORIA STATION AND ROOF, L. C. & D. AND G. W. R. (6 PLATES); ROOF OF CREMORNE MUSIC HALL; BRIDGE OVER G. N. RAILWAY; ROOF OF STATION, DUTCH RHENISH RAIL. (2 PLATES); BRIDGE OVER THE THAMES, WEST LONDON EXTENSION RAILWAY (5 PLATES); ARMOUR PLATES; SUSPENSION BRIDGE, THAMES (4 PLATES); THE ALLEN ENGINE; SUSPENSION BRIDGE, AVON (3 PLATES); UNDERGROUND RAILWAY (3 PLATES).

HUMBER'S MODERN ENGINEERING.

SECOND SERIES. Imp. 4to, with 3 Double Plates, Photographic Portrait of Robert Stephenson, C.E., M.P., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c. Half-morocco . . . . . £3 3s.

LIST OF THE PLATES AND DIAGRAMS.

BIRKENHEAD DOCKS, LOW WATER BASIN (15 PLATES); CHARING CROSS STATION ROOF, C. C. RAILWAY (3 PLATES); DIGSWELL VIADUCT, GREAT NORTHERN RAILWAY; ROBBERY WOOD VIADUCT, GREAT NORTHERN RAILWAY; IRON PERMANENT WAY; CLYDACH VIADUCT, MERTHYR, TREDEGAR, AND ABERGAVENNY RAILWAY; EBBW VIADUCT, MERTHYR, TREDEGAR, AND ABERGAVENNY RAILWAY; COLLEGE WOOD VIADUCT, CORNWALL RAILWAY; DUBLIN WINTER PALACE ROOF (3 PLATES); BRIDGE OVER THE THAMES, L. C. & D. RAILWAY (6 PLATES); ALBERT HARBOUR, GREENOCK (4 PLATES).

HUMBER'S MODERN ENGINEERING.

THIRD SERIES. Imp. 4to, with 40 Double Plates, Photographic Portrait of J. R. M'Clean, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c. Half-morocco . . . . . £3 3s.

LIST OF THE PLATES AND DIAGRAMS.

MAIN DRAINAGE, METROPOLIS.—*North Side.*—MAP SHOWING INTERCEPTION OF SEWERS: MIDDLE LEVEL SEWER (2 PLATES); OUTFALL SEWER, BRIDGE OVER RIVER LEA (3 PLATES); OUTFALL SEWER, BRIDGE OVER MARSH LANE, NORTH WOOLWICH RAILWAY, AND BOW AND BARKING RAILWAY JUNCTION; OUTFALL SEWER, BRIDGE OVER BOW AND BARKING RAILWAY (3 PLATES); OUTFALL SEWER, BRIDGE OVER EAST LONDON WATER-WORKS' FEEDER (2 PLATES); OUTFALL SEWER RESERVOIR (2 PLATES); OUTFALL SEWER, TUMBLING BAY AND OUTLET; OUTFALL SEWER, PENSTOCKS. *South Side.*—OUTFALL SEWER, BERMONDSEY BRANCH (2 PLATES); OUTFALL SEWER, RESERVOIR AND OUTLET (4 PLATES); OUTFALL SEWER, FILTH HOIST; SECTIONS OF SEWERS (NORTH AND SOUTH SIDES).

THAMES EMBANKMENT.—SECTION OF RIVER WALL; STEAMBOAT PIER, WESTMINSTER (2 PLATES); LANDING STAIRS BETWEEN CHARING CROSS AND WATERLOO BRIDGES: YORK GATE (2 PLATES); OVERFLOW AND OUTLET AT SAVOY STREET SEWER (3 PLATES); STEAMBOAT PIER, WATERLOO BRIDGE (3 PLATES); JUNCTION OF SEWERS, PLANS AND SECTIONS; GULLIES, PLANS AND SECTIONS; ROLLING STOCK; GRANITE AND IRON FORTS.

HUMBER'S MODERN ENGINEERING.

FOURTH SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of John Fowler, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c. Half-morocco . . . . . £3 3s.

LIST OF THE PLATES AND DIAGRAMS.

ABBEY MILLS PUMPING STATION, MAIN DRAINAGE, METROPOLIS (4 PLATES); BARROW DOCKS (5 PLATES); MANQUIS VIADUCT, SANTIAGO AND VALPARAISO RAILWAY (2 PLATES); ADAM'S LOCOMOTIVE, ST. HELEN'S CANAL RAILWAY (2 PLATES); CANNON STREET STATION ROOF, CHARING CROSS RAILWAY (3 PLATES); ROAD BRIDGE OVER THE RIVER MOKA (2 PLATES); TELEGRAPHIC APPARATUS FOR MESOPOTAMIA; VIADUCT OVER THE RIVER WYE, MIDLAND RAILWAY (3 PLATES); ST. GERMANS VIADUCT, CORNWALL RAILWAY (2 PLATES); WROUGHT-IRON CYLINDER FOR DIVING BELL; MILLWALL DOCKS (6 PLATES); MILROY'S PATENT EXCAVATOR; METROPOLITAN DISTRICT RAILWAY (6 PLATES); HARBOURS, PORTS, AND BREAKWATERS (3 PLATES).

MARINE ENGINEERING, SHIPBUILDING, NAVIGATION, &c.

THE NAVAL ARCHITECT'S AND SHIPBUILDER'S POCKET-BOOK

of Formulæ, Rules, and Tables, and Marine Engineer's and Surveyor's Handy Book of Reference. By CLEMENT MACKROW, M.I.N.A. Seventh Edition, 700 pp., with 300 Illustrations. Fcap., leather . . **12/6**

SUMMARY OF CONTENTS.—SIGNS AND SYMBOLS, DECIMAL FRACTIONS.—TRIGONOMETRY.—PRACTICAL GEOMETRY.—MENSURATION.—CENTRES AND MOMENTS OF FIGURES.—MOMENTS OF INERTIA AND RADII OF GYRATION.—ALGEBRAICAL EXPRESSIONS FOR SIMPSON'S RULES.—MECHANICAL PRINCIPLES.—CENTRE OF GRAVITY.—LAWS OF MOTION.—DISPLACEMENT, CENTRE OF BUOYANCY.—CENTRE OF GRAVITY OF SHIP'S HULL.—STABILITY CURVES AND METACENTRES.—SEA AND SHALLOW-WATER WAVES.—ROLLING OF SHIPS.—PROPULSION AND RESISTANCE OF VESSELS.—SPEED TRIALS.—SAILING, CENTRE OF EFFORT.—DISTANCES DOWN RIVERS, COAST LINES.—STEERING AND RUDDERS OF VESSELS.—LAUNCHING CALCULATIONS AND VELOCITIES.—WEIGHT OF MATERIAL AND GEAR.—GUN PARTICULARS AND WEIGHT.—STANDARD GAUGES.—RIVETED JOINTS AND RIVETING.—STRENGTH AND TESTS OF MATERIALS.—BINDING AND SHEARING STRESSES, &c.—STRENGTH OF SHAFTING, PILLARS, WHEELS, &c.—HYDRAULIC DATA, &c.—CONIC SECTIONS, CATENARIAN CURVES.—MECHANICAL POWERS, WORK.—BOARD OF TRADE REGULATIONS FOR BOILERS AND ENGINES.—BOARD OF TRADE REGULATIONS FOR SHIPS.—LLOYD'S RULES FOR BOILERS.—LLOYD'S WEIGHT OF CHAINS.—LLOYD'S SCANTLINGS FOR SHIPS.—DATA OF ENGINES AND VESSELS.—SHIPS' FITTINGS AND TESTS.—SEASONING, PRESERVING TIMBER.—MEASUREMENT OF TIMBER.—ALLOYS, PAINTS, VARNISHES.—DATA FOR STOWAGE.—ADMIRALTY TRANSPORT REGULATIONS.—RULES FOR HORSE-POWER, SCREW PROPELLERS, &c.—PERCENTAGES FOR BUTT STRAPS, &c.—PARTICULARS OF YACHTS.—MASTING AND RIGGING VESSELS.—DISTANCES OF FOREIGN PORTS.—TONNAGE TABLES.—VOCABULARY OF FRENCH AND ENGLISH TERMS.—ENGLISH WEIGHTS AND MEASURES.—FOREIGN WEIGHTS AND MEASURES.—DECIMAL EQUIVALENTS.—FOREIGN MONEY.—DISCOUNT AND WAGES TABLES.—USEFUL NUMBERS AND READY RECKONERS.—TABLES OF CIRCULAR MEASURES.—TABLES OF AREAS OF AND CIRCUMFERENCES OF CIRCLES.—TABLES OF AREAS OF SEGMENTS OF CIRCLES.—TABLES OF SQUARES AND CUBES AND ROOTS OF NUMBERS.—TABLES OF LOGARITHMS OF NUMBERS.—TABLES OF HYPERBOLIC LOGARITHMS.—TABLES OF NATURAL SINES, TANGENTS, &c.—TABLES OF LOGARITHMIC SINES, TANGENTS, &c.

"In these days of advanced knowledge a work like this is of the greatest value. It contains a vast amount of information. We unhesitatingly say that it is the most valuable compilation for its specific purpose that has ever been printed. No naval architect, engineer, surveyor, or seaman, wood or iron shipbuilder, can afford to be without this work."—*Nautical Magazine.*

"Should be used by all who are engaged in the construction or design of vessels. . . . Will be found to contain the most useful tables and formulæ required by shipbuilders, carefully collected from the best authorities, and put together in a popular and simple form. The book is one of exceptional merit."—*Engineer.*

"The professional shipbuilder has now, in a convenient and accessible form, reliable data for solving many of the numerous problems that present themselves in the course of his work."—*Iron.*

"There is no doubt that a pocket-book of this description must be a necessity in the shipbuilding trade. . . The volume contains a mass of useful information clearly expressed and presented in a handy form."—*Marine Engineer.*

WANNAN'S MARINE ENGINEER'S GUIDE

To Board of Trade Examinations for Certificates of Competency. Containing all Latest Questions to Date, with Simple, Clear, and Correct Solutions; Elementary and Verbal Questions and Answers; complete Set of Drawings with Statements completed. By A. C. WANNAN, C.E., and E. W. I. WANNAN, M.I.M.E. Illustrated with numerous Engravings. Crown 8vo, 370 pages, cloth. [*Just Published.* **8/6**

"The book is clearly and plainly written and avoids unnecessary explanations and formulas, and we consider it a valuable book for students of marine engineering."—*Nautical Magazine.*

WANNAN'S MARINE ENGINEER'S POCKET-BOOK.

Containing the Latest Board of Trade Rules and Data for Marine Engineers. By A. C. WANNAN. Second Edition, carefully Revised. Square 18mo, with thumb Index, leather. [*Just Published.* **5/0**

"There is a great deal of useful information in this little pocket book. It is of the rule-of-thumb order, and is, on that account, well adapted to the uses of the sea-going engineer."—*Engineer.*

MARINE ENGINES AND STEAM VESSELS.

A Treatise on. By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with considerable Additions by the Author and by GEORGE CARLISLE, C.E., Senior Surveyor to the Board of Trade. 12mo, cloth . **4/6**

SEA TERMS, PHRASES, AND WORDS

(Technical Dictionary of) used in the English and French Languages (English-French, French-English). For the Use of Seamen, Engineers, Pilots, Shipbuilders, Shipowners, and Ship-brokers. Compiled by W. PIRRIE, late of the African Steamship Company. Fcap. 8vo, cloth limp . . . 5/0

"This volume will be highly appreciated by seamen, engineers, pilots, shipbuilders and shipowners. It willdbe found wonderfully accurate and complete."—*Scotsman.*

"A very useful dictionary, which has long been wanted by French and English engineers, masters, officers and others."—*Shipping World.*

ELECTRIC SHIP-LIGHTING.

A Handbook on the Practical Fitting and Running of Ships' Electrical Plant, for the Use of Shipowners and Builders, Marine Electricians and Sea-going Engineers in Charge. By J. W. URQUHART, Author of "Electric Light," "Dynamo Construction." &c. Second Edition, Revised and Extended. 326 pp., with 88 Illustrations. Crown 8vo, cloth. [*Just Published.* 7/6

MARINE ENGINEER'S POCKET-BOOK.

Consisting of useful Tables and Formulæ. By FRANK PROCTOR, A.I.N.A. Third Edition. Royal 32mo, leather, gilt edges, with strap . . . 4/0

"We recommend it to our readers as going far to supply a long-felt want."—*Naval Science.*

"A most useful companion to all marine engineers."—*United Service Gazette.*

ELEMENTARY ENGINEERING.

A Manual for Young Marine Engineers and Apprentices. In the Form of Questions and Answers on Metals, Alloys, Strength of Materials, Construction and Management of Marine Engines and Boilers, Geometry, &c., &c. With an Appendix of Useful Tables. By J. S. BREWER. Crown 8vo, cloth . 1/6

"Contains much valuable information for the class for whom it is intended, especially in the chapters on the management of boilers and engines."—*Nautical Magazine.*

PRACTICAL NAVIGATION.

Consisting of THE SAILOR'S SEA-BOOK, by JAMES GREENWOOD and W. H. ROSSER; together with the exquisite Mathematical and Nautical Tables for the Working of the Problems, by HENRY LAW, C.E., and Professor J. R. YOUNG. Illustrated. 12mo, strongly half-bound 7/0

MARINE ENGINEER'S DRAWING-BOOK.

Adapted to the Requirements of the Board of Trade Examinations. By JOHN LOCKIE, C.E. With 22 Plates, Drawn to Scale. Royal 8vo, cloth . 3/6

THE ART AND SCIENCE OF SAILMAKING.

By SAMUEL B. SADLER, Practical Sailmaker, late in the employment of Messrs. Ratsey and Lapthorne, of Cowes and Gosport. With Plates and other Illustrations. Small 4to, cloth 12/6

"This extremely practical work gives a complete education in all the branches of the manufacture, cutting out, roping, seaming, and goring. It is copiously illustrated, and will form a first rate text-book and guide."—*Portsmouth Times.*

CHAIN CABLES AND CHAINS.

Comprising Sizes and Curves of Links, Studs, &c., Iron for Cables and Chains, Chain Cable and Chain Making, Forming and Welding Links, Strength of Cables and Chains, Certificates for Cables, Marking Cables, Prices of Chain Cables and Chains, Historical Notes, Acts of Parliament, Statutory Tests, Charges for Testing, List of Manufacturers of Cables, &c., &c. By THOMAS W. TRAILL, F.E.R.N., M.Inst.C.E., Engineer-Surveyor-in-Chief, Board of Trade, Inspector of Chain Cable and Anchor Proving Establishments, and General Superintendent Lloyd's Committee on Proving Establishments. With numerous Tables, Illustrations, and Lithographic Drawings. Folio, cloth, bevelled boards . . . . . £2 2s.

"It contains a vast amount of valuable information. Nothing seems to be wanting to make it a complete and standard work of reference on the subject."—*Nautical Magazine.*

MINING AND METALLURGY.

COLLIERY WORKING AND MANAGEMENT.

Comprising the Duties of a Colliery Manager, the Oversight and Arrangement of Labour and Wages, and the different Systems of Working Coal Seams. By H. F. BULMAN and R. A. S. REDMAYNE. 350 pp., with 28 Plates and other Illustrations, including Underground Photographs. Medium 8vo, cloth. [*Just Published.* **15/0**

"This is, indeed, an admirable Handbook for Colliery Managers, in fact it is an indispensable adjunct to a Colliery Manager's education, as well as being a most useful and interesting work on the subject for all who in any way have to do with coal mining. The underground photographs are an attractive feature of the work, being very lifelike and necessarily true representations of the scenes they depict."—*Colliery Guardian.*

"Mr. Bulman and Mr. Redmayne, who are both experienced Colliery Managers of great literary ability, are to be congratulated on having supplied an authoritative work dealing with a side of the subject of coal mining which has hitherto received but scant treatment. The authors elucidate their text by 119 woodcuts and 28 plates, most of the latter being admirable reproductions of photographs taken underground with the aid of the magnesium flash-light. These illustrations are excellent."—*Nature.*

INFLAMMABLE GAS AND VAPOUR IN THE AIR

(The Detection and Measurement of). By FRANK CLOWES, D.Sc., Lond., F.I.C., Prof. of Chemistry in the University College, Nottingham. With a Chapter on THE DETECTION AND MEASUREMENT OF PETROLEUM VAPOUR by BOVERTON REDWOOD, F.R.S.E., Consulting Adviser to the Corporation of London under the Petroleum Acts. Crown 8vo, cloth.

[*Just Published. Net* **5/0**

"Professor Clowes has given us a volume on a subject of much industrial importance . . . Those interested in these matters may be recommended to study this book, which is easy of comprehension and contains many good things."—*The Engineer.*

"A convenient summary of the work on which Professor Clowes has been engaged for some considerable time. . . . It is hardly necessary to say that any work on these subjects with these names on the title-page must be a valuable one, and one that no mining engineer—certainly no coal miner—can afford to ignore or to leave unread."—*Mining Journal.*

MACHINERY FOR METALLIFEROUS MINES.

A Practical Treatise for Mining Engineers, Metallurgists, and Managers of Mines. By E. HENRY DAVIES, M.E., F.G.S. Crown 8vo, 580 pp., with upwards of 300 Illustrations, cloth. **12/6**

"Mr. Davies, in this handsome volume, has done the advanced student and the manager of mines good service. Almost every kind of machinery in actual use is carefully described, and the woodcuts and plates are good."—*Athenæum.*

"From cover to cover the work exhibits all the same characteristics which excite the confidence and attract the attention of the student as he peruses the first page. The work may safely be recommended. By its publication the literature connected with the industry will be enriched and the reputation of its author enhanced."—*Mining Journal.*

METALLIFEROUS MINERALS AND MINING.

By D. C. DAVIES, F.G.S., Mining Engineer, &c., Author of "A Treatise on Slate and Slate Quarrying." Fifth Edition, thoroughly Revised and much Enlarged by his Son, E. HENRY DAVIES, M.E., F.G.S. With about 150 Illustrations. Crown 8vo, cloth **12/6**

"Neither the practical miner nor the general reader, interested in mines, can have a better book for his companion and his guide."—*Mining Journal.*

"We are doing our readers a service in calling their attention to this valuable work."—*Mining World.*

"As a history of the present state of mining throughout the world this book has a real value and it supplies an actual want."—*Athenæum.*

EARTHY AND OTHER MINERALS AND MINING.

By D. C. DAVIES, F.G.S., Author of "Metalliferous Minerals," &c. Third Edition, Revised and Enlarged by his Son, E. HENRY DAVIES, M.E., F.G.S. With about 100 Illustrations. Crown 8vo, cloth **12/6**

"We do not remember to have met with any English work on mining matters that contains the same amount of information packed in equally convenient form."—*Academy.*

"We should be inclined to rank it as among the very best of the handy technical and trades manuals which have recently appeared."—*British Quarterly Review.*

THE COLLIERY MANAGER'S HANDBOOK.

A Comprehensive Treatise on the Laying-out and Working of Collieries, Designed as a Book of Reference for Colliery Managers, and for the Use of Coal Mining Students preparing for First-class Certificates. By CALEB PAMELY, Mining Engineer and Surveyor; Member of the North of England Institute of Mining and Mechanical Engineers; and Member of the South Wales Institute of Mining Engineers. With 700 Plans, Diagrams, and other Illustrations. Fourth Edition, Revised and Enlarged, medium 8vo, over 900 pp. Strongly bound . . . . . **£1 5s.**

SUMMARY OF CONTENTS:—GEOLOGY.—SEARCH FOR COAL.—MINERAL LEASES AND OTHER HOLDINGS.—SHAFT SINKING.—FITTING UP THE SHAFT AND SURFACE ARRANGEMENTS.—STEAM BOILERS AND THEIR FITTINGS.—TIMBERING AND WALLING.—NARROW WORK AND METHODS OF WORKING.—UNDERGROUND CONVEYANCE.—DRAINAGE.—THE GASES MET WITH IN MINES; VENTILATION.—ON THE FRICTION OF AIR IN MINES.—THE PRIESTMAN OIL ENGINE; PETROLEUM AND NATURAL GAS.—SURVEYING AND PLANNING.—SAFETY LAMPS AND FIREDAMP DETECTORS.—SUNDRY AND INCIDENTAL OPERATIONS AND APPLIANCES.—COLLIERY EXPLOSIONS.—MISCELLANEOUS QUESTIONS AND ANSWERS.—*Appendix*: SUMMARY OF REPORT OF H.M. COMMISSIONERS ON ACCIDENTS IN MINES.

"Mr. Pamely has not only given us a comprehensive reference book of a very high order, suitable to the requirements of mining engineers and colliery managers, but has also provided mining students with a class book that is as interesting as it is instructive."—*Colliery Manager.*

"Mr. Pamely's work is eminently suited to the purpose for which it is intended, being clear, interesting, exhaustive, rich in detail, and up to date, giving descriptions of the latest machines in every department. A mining engineer could scarcely go wrong who followed this work."—*Colliery Guardian.*

"This is the most complete 'all round' work on coal-mining published in the English language. . . . No library of coal mining books is complete without it."—*Colliery Engineer* (Scranton, Pa., U.S.A.).

COAL & IRON INDUSTRIES of the UNITED KINGDOM.

Comprising a Description of the Coal Fields, and of the Principal Seams of Coal, with Returns of their Produce and its Distribution, and Analyses of Special Varieties. Also, an Account of the Occurrence of Iron Ores in Veins or Seams; Analyses of each Variety; and a History of the Rise and Progress of Pig Iron Manufacture. By RICHARD MEADE. 8vo, cloth . . **£1 8s.**

"Of this book we may unreservedly say that it is the best of its class which we have ever met. . . . A book of reference which no one engaged in the iron or coal trades should omit from his library."—*Iron and Coal Trades Review.*

TRAVERSE TABLES.

For use in Mine Surveying. By W. LINTERN, Mining Engineer. Crown 8vo, cloth. [*Just Published. Net* **3/0**

COAL AND COAL MINING.

By the late Sir WARINGTON W. SMYTH, F.R.S., Chief Inspector of the Mines of the Crown. Eighth Edition, Revised and Extended by T. FORSTER BROWN, Mining Engineer, Chief Inspector of the Mines of the Crown and of the Duchy of Cornwall. Crown 8vo, cloth. [*Just Published.* **3/6**

"As an outline is given of every known coal-field in this and other countries, as well as of the principal methods of working, the book will doubtless interest a very large number of readers."—*Mining Journal.*

ASBESTOS AND ASBESTIC.

Their Properties, Occurrence, and Use. By ROBERT H. JONES, F.S.A., Mineralogist, Hon. Mem. Asbestos Club, Black Lake, Canada. With Ten Collotype Plates and other Illustrations. Demy 8vo, cloth. [*Just Published.* **16/0**

"An interesting and invaluable work."—*Colliery Guardian.*

SUBTERRANEOUS SURVEYING

(Elementary and Practical Treatise on), with and without the Magnetic Needle. By THOMAS FENWICK, Surveyor of Mines, and THOMAS BAKER, C.E. Illustrated. 12mo, cloth **2/6**

GRANITES AND OUR GRANITE INDUSTRIES.

By GEORGE F. HARRIS, F.G.S., Membre de la Société Belge de Géologie, Lecturer on Economic Geology at the Birkbeck Institution, &c. With Illustrations. Crown 8vo, cloth **2/6**

"A clearly and well-written manual for persons engaged or interested in the granite industry."—*Scotsman.*

THE METALLURGY OF GOLD.

A Practical Treatise on the Metallurgical Treatment of Gold-bearing Ores. Including the Processes of Concentration, Chlorination, and Extraction by Cyanide, and the Assaying, Melting, and Refining of Gold. By M. EISSLER, Mining Engineer and Metallurgical Chemist, formerly Assistant Assayer of the U.S. Mint, San Francisco. Fourth Edition, Enlarged. With about 250 Illustrations and numerous Folding Plates and Working Drawings. Large crown 8vo, cloth. [*Just Published.* 16/0

"This book thoroughly deserves its title of a 'Practical Treatise.' The whole process of gold milling, from the breaking of the quartz to the assay of the bullion, is described in clear and orderly narrative and with much, but not too much, fulness of detail."—*Saturday Review.*

"The work is a storehouse of information and valuable data, and we strongly recommend it to all professional men engaged in the gold mining industry."—*Mining Journal.*

THE CYANIDE PROCESS OF GOLD EXTRACTION.

Including its Practical Application on the Witwatersrand Gold Fields in South Africa. By M. EISSLER, M.E., Author of "The Metallurgy of Gold," &c. With Diagrams and Working Drawings. Second Edition, Revised and Enlarged. 8vo, cloth. [*Just Published.* 7/6

"This book is just what was needed to acquaint mining men with the actual working of a process which is not only the most popular but is, as a general rule, the most successful for the extraction of gold from tailings."—*Mining Journal.*

"The work will prove invaluable to all interested in gold mining, whether metallurgists or as investors."—*Chemical News*

THE METALLURGY OF SILVER.

A Practical Treatise on the Amalgamation, Roasting, and Lixiviation of Silver Ores. Including the Assaying, Melting, and Refining of Silver Bullion. By M. EISSLER, Author of "The Metallurgy of Gold," &c. Third Edition. Crown 8vo, cloth 10/6

"A practical treatise, and a technical work which we are convinced will supply a long-felt want amongst practical men, and at the same time be of value to students and others indirectly connected with the industries."—*Mining Journal.*

"From first to last the book is thoroughly sound and reliable."—*Colliery Guardian.*

"For chemists, practical miners, assayers, and investors alike we do not know of any work on the subject so handy and yet so comprehensive."—*Glasgow Herald.*

THE METALLURGY OF ARGENTIFEROUS LEAD.

A Practical Treatise on the Smelting of Silver-Lead Ores and the Refining of Lead Bullion. Including Reports on various Smelting Establishments and Descriptions of Modern Smelting Furnaces and Plants in Europe and America. By M. EISSLER, M.E., Author of "The Metallurgy of Gold," &c. Crown 8vo, 400 pp., with 183 Illustrations, cloth 12/6

"The numerous metallurgical processes, which are fully and extensively treated of, embrace all the stages experienced in the passage of the lead from the various natural states to its issue from the refinery as an article of commerce."—*Practical Engineer.*

"The present volume fully maintains the reputation of the author. Those who wish to obtain a thorough insight into the present state of this industry cannot do better than read this volume, and all mining engineers cannot fail to find many useful hints and suggestions in it."—*Industries.*

METALLURGY OF IRON.

By H. BAUERMAN, F.G.S., A.R.S.M. Sixth Edition, Revised and Enlarged. 12mo, cloth 5/0

THE IRON ORES of GREAT BRITAIN and IRELAND.

Their Mode of Occurrence, Age and Origin, and the Methods of Searching for and Working Them. With a Notice of some of the Iron Ores of Spain. By J. D. KENDALL, F.G.S., Mining Engineer. Crown 8vo, cloth . . 16/0

"The author has a thorough practical knowledge of his subject, and has supplemented a careful study of the available literature by unpublished information derived from his own observations. The result is a very useful volume, which cannot fail to be of value to all interested in the iron industry of the country."—*Industries.*

ELECTRICITY, ELECTRICAL ENGINEERING, &c.

SUBMARINE TELEGRAPHS.

Their History, Construction, and Working. Founded in part on WÜNSCHENDORFF'S "Traité de Télégraphie Sous-Marine," and Compiled from Authoritative and Exclusive Sources. By CHARLES BRIGHT, F.R.S.E. Super royal 8vo, about 780 pp., fully Illustrated, including Maps and Folding Plates.

[*Just Published.* *Net* **£3 3s.**

"There are few, if any, persons more fitted to write a treatise on submarine telegraphy than Mr. Charles Bright. The author has done his work admirably, and has written in a way which will appeal as much to the layman as to the engineer. This admirable volume must, for many years to come, hold the position of the English classic on submarine telegraphy."—*Engineer.*

"This book is full of information. It makes a book of reference which should be in every engineer's library."—*Nature.*

"Mr. Bright's interestingly written and admirably illustrated book will meet with a welcome reception from cable men."—*Electrician.*

"The author deals with his subject from all points of view—political and strategical as well as scientific. The work will be of interest, not only to men of science, but to the general public. We can strongly recommend it."—*Athenæum*

"The work contains a great store of technical information concerning the making and working of submarine telegraphs. In bringing together the most valuable results relating to the evolution of the telegraph, the author has rendered a service that will be very widely appreciated."—*Morning Post.*

THE ELECTRICAL ENGINEER'S POCKET-BOOK.

Consisting of Modern Rules, Formulæ, Tables, and Data. By H. R. KEMPE, M.Inst.E.E., A.M.Inst.C.E., Technical Officer Postal Telegraphs, Author of "A Handbook of Electrical Testing," "The Engineer's Year-Book," &c. Second Edition, thoroughly Revised, with Additions. With numerous Illustrations. Royal 32mo, oblong, leather **5/0**

"It is the best book of its kind."—*Electrical Engineer.*

"The Electrical Engineer's Pocket Book is a good one."—*Electrician.*

"Strongly recommended to those engaged in the electrical industries."—*Electrical Review.*

ELECTRIC LIGHT FITTING.

A Handbook for Working Electrical Engineers, embodying Practical Notes on Installation Management. By J. W. URQUHART, Electrician, Author of "Electric Light," &c. With numerous Illustrations. Third Edition, Revised, with Additions. Crown 8vo, cloth. [*Just Published.* **5/0**

"This volume deals with what may be termed the mechanics of electric lighting, and is addressed to men who are already engaged in the work, or are training for it. The work traverses a great deal of ground, and may be read as a sequel to the same author's useful work on 'Electric Light.'—*Electrician*

"Eminently practical and useful . . . Ought to be in the hands of every one in charge of an electric light plant.—*Electrical Engineer*

ELECTRIC LIGHT.

Its Production and Use, Embodying Plain Directions for the Treatment of Dynamo-Electric Machines, Batteries, Accumulators, and Electric Lamps. By J. W. URQUHART, C.E. Sixth Edition, Revised with Additions and 145 Illustrations. Crown 8vo, cloth. [*Just Published* **7/6**

"The whole ground of electric lighting is more or less covered and explained in a very clear and concise manner.—*Electrical Review*

"A *vade-mecum* of the salient facts connected with the science of electric lighting."—*Electrician.*

"You cannot for your purpose have a better book than 'Electric Light' by Urquhart.'—*Engineer.*

DYNAMO CONSTRUCTION.

A Practical Handbook for the Use of Engineer-Constructors and Electricians-in-Charge. Embracing Framework Building, Field Magnet and Armature Winding and Grouping, Compounding, &c. With Examples of leading English, American, and Continental Dynamos and Motors. By J. W. URQUHART, Author of "Electric Light," &c. Second Edition, Enlarged. With 114 Illustrations. Crown 8vo, cloth **7/6**

"Mr. Urquhart's book is the first one which deals with these matters in such a way that the engineering student can understand them. The book is very readable, and the author leads his readers up to difficult subjects by reasonably simple tests.—*Engineering Review.*

"A book for which a demand has long existed."—*Mechanical World.*

THE MANAGEMENT OF DYNAMOS.

A Handy Book of Theory and Practice for the Use of Mechanics, Engineers, Students, and others in Charge of Dynamos. By G. W. LUMMIS-PATERSON. Second Edition, thoroughly Revised and Enlarged. With numerous Illustrations. Crown 8vo, cloth. [*Just Published.* 4/6

"An example which deserves to be taken as a model by other authors. The subject is treated in a manner which any intelligent man who is fit to be entrusted with charge of an engine should be able to understand. It is a useful book to all who make, tend, or employ electric machinery."—*Architect.*

THE STANDARD ELECTRICAL DICTIONARY.

A Popular Encyclopædia of Words and Terms Used in the Practice of Electrical Engineering. By T. O'CONOR SLOANE, A.M., Ph.D. Second Edition, with Appendix to date. Crown 8vo, 680 pp., 390 Illustrations, cloth. [*Just Published.* 7/6

"The work has many attractive features in it, and is, beyond doubt, a well put together and useful publication. The amount of ground covered may be gathered from the fact that in the index about 5,600 references will be found."—*Electrical Review.*

ELECTRIC SHIP-LIGHTING.

A Handbook on the Practical Fitting and Running of Ships' Electrical Plant. For the Use of Shipowners and Builders, Marine Electricians, and Seagoing Engineers-in-Charge. By J. W. URQUHART, C.E. Second Edition, Revised and Extended. 326 pp., with 88 Illustrations, Crown 8vo, cloth. [*Just Published.* 7/6

"The subject of ship electric lighting is one of vast importance, and Mr. Urquhart is to be highly complimented for placing such a valuable work at the service of marine electricians."—*The Steamship.*

ELECTRIC LIGHT FOR COUNTRY HOUSES.

A Practical Handbook on the Erection and Running of Small Installations, with Particulars of the Cost of Plant and Working. By J. H. KNIGHT. Second Edition, Revised. Crown 8vo, wrapper. [*Just Published.* 1/0

"The book contains excellent advice and many practical hints for the help of those who wish to light their own houses."—*Building News.*

ELECTRIC LIGHTING (ELEMENTARY PRINCIPLES OF).

By ALAN A. CAMPBELL SWINTON, Associate I.E.E. Fourth Edition, Enlarged and Revised. With 16 Illustrations. Crown 8vo, cloth 1/6

"Any one who desires a short and thoroughly clear exposition of the elementary principles of electric lighting cannot do better than read this little work."—*Bradford Observer.*

DYNAMIC ELECTRICITY AND MAGNETISM.

By PHILIP ATKINSON, A.M., Ph.D., Author of "Elements of Static Electricity," &c. Crown 8vo, 417 pp., with 120 Illustrations, cloth . 10/6

POWER TRANSMITTED BY ELECTRICITY

And applied by the Electric Motor, including Electric Railway Construction. By P. ATKINSON, A.M., Ph.D. With 96 Illustrations. Crown 8vo, cloth 7/6

HOW TO MAKE A DYNAMO.

A Practical Treatise for Amateurs. Containing numerous Illustrations and Detailed Instructions for Constructing a Small Dynamo to Produce the Electric Light. By ALFRED CROFTS. Fifth Edition, Revised and Enlarged. Crown 8vo, cloth. [*Just Published.* 2/0

"The instructions given in this unpretentious little book are sufficiently clear and explicit to enable any amateur mechanic possessed of average skill and the usual tools to be found in an amateur's workshop to build a practical dynamo machine."—*Electrician.*

THE STUDENT'S TEXT-BOOK OF ELECTRICITY.

By H. M. NOAD, F.R.S. Cheaper Edition. 650 pp., with 470 Illustrations. Crown 8vo, cloth 9/0

ARCHITECTURE, BUILDING, &c.

PRACTICAL BUILDING CONSTRUCTION.

A Handbook for Students Preparing for Examinations, and a Book of Reference for Persons Engaged in Building. By JOHN PARNELL ALLEN, Surveyor, Lecturer on Building Construction at the Durham College of Science, Newcastle-on-Tyne. Third Edition, Revised and Enlarged. Medium 8vo, 450 pp., with 1,000 Illustrations, cloth. [*Just Published.* **7/6**

"The most complete exposition of building construction we have seen. It contains all that is necessary to prepare students for the various examinations in building construction."—*Building News.*

"The author depends nearly as much on his diagrams as on his type. The pages suggest the hand of a man of experience in building operations—and the volume must be a blessing to many teachers as well as to students."—*The Architect.*

"The work is sure to prove a formidable rival to great and small competitors alike, and it is fair to take a permanent place as a favourite student's text book. The large number of illustrations deserve particular mention for the great merit they possess for purposes of reference in exactly corresponding to convenient scales."—*Journal of the Royal Institute of British Architects.*

PRACTICAL MASONRY.

A Guide to the Art of Stone Cutting. Comprising the Construction, Setting Out, and Working of Stairs, Circular Work, Arches, Niches, Domes, Pendentives, Vaults, Tracery Windows, &c., &c. For the Use of Students, Masons, and other Workmen. By WILLIAM R. PURCHASE, Building Inspector to the Borough of Hove. Third Edition, with Glossary of Terms. Royal 8vo, 142 pp., with 52 Lithographic Plates, comprising nearly 400 separate Diagrams, cloth. [*Just Published.* **7/6**

"Mr. Purchase's 'Practical Masonry' will undoubtedly be found useful to all interested in this important subject, whether theoretically or practically. Most of the examples given are from actual work carried out, the diagrams being carefully drawn. The book is a practical treatise on the subject, the author himself having commenced as an operative mason, and afterwards acted as foreman mason on many large and important buildings prior to the attainment of his present position. It should be found of general utility to architectural students and others, as well as to those to whom it is specially addressed."—*Journal of the Royal Institute of British Architects.*

CONCRETE: ITS NATURE AND USES.

A Book for Architects, Builders, Contractors, and Clerks of Works. By GEORGE L. SUTCLIFFE, A.R.I.B.A. 350 pp., with numerous Illustrations. Crown 8vo, cloth **7/6**

"The author treats a difficult subject in a lucid manner. The manual fills a long-felt gap. It is careful and exhaustive; equally useful as a student's guide and an architect's book of reference."—*Journal of the Royal Institute of British Architects.*

"There is room for this new book, which will probably be for some time the standard work on the subject for a builder's purpose."—*Glasgow Herald.*

THE MECHANICS OF ARCHITECTURE.

A Treatise on Applied Mechanics, especially Adapted to the Use of Architects. By E. W. TARN, M.A., Author of "The Science of Building," &c. Second Edition, Enlarged. Illustrated with 125 Diagrams. Crown 8vo, cloth **7/6**

"The book is a very useful and helpful manual of architectural mechanics, and really contains sufficient to enable a careful and painstaking student to grasp the principles bearing upon the majority of building problems. . . . Mr. Tarn has added, by this volume, to the debt of gratitude which is owing to him by architectural students for the many valuable works which he has produced for their use."—*The Builder.*

LOCKWOOD'S BUILDER'S PRICE BOOK for 1900.

A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers, and Contractors. Re-constructed, Re-written, and Greatly Enlarged. By FRANCIS T. W. MILLER. 800 closely-printed pages, crown 8vo, cloth **4/0**

"This book is a very useful one, and should find a place in every English office connected with the building and engineering professions."—*Industries.*

"An excellent book of reference."—*Architect.*

"In its new and revised form this Price Book is what a work of this kind should be—comprehensive, reliable, well arranged, legible, and well bound."—*British Architect.*

THE DECORATIVE PART OF CIVIL ARCHITECTURE.

By Sir WILLIAM CHAMBERS, F.R.S. With Portrait, Illustrations, Notes, and an EXAMINATION OF GRECIAN ARCHITECTURE, by JOSEPH GWILT, F.S.A. Revised and Edited by W. H. LEEDS. 66 Plates, 4to, cloth . . . **21/0**

A HANDY BOOK OF VILLA ARCHITECTURE.

Being a Series of Designs for Villa Residences in various Styles. With Outline Specifications and Estimates. By C. WICKES, Architect, Author of "The Spires and Towers of England," &c. 61 Plates, 4to, half-morocco, gilt edges . . . . . £1 11s. 6d.

"The whole of the designs bear evidence of their being the work of an artistic architect, and they will prove very valuable and suggestive."—*Building News.*

THE ARCHITECT'S GUIDE.

Being a Text-book of Useful Information for Architects, Engineers, Surveyors Contractors, Clerks of Works, &c., &c. By FREDERICK ROGERS, Architect. Third Edition. Crown 8vo, cloth 3/6

"As a text-book of useful information for architects, engineers, surveyors, &c., it would be hard to find a handier or more complete little volume."—*Standard.*

ARCHITECTURAL PERSPECTIVE.

The whole Course and Operations of the Draughtsman in Drawing a Large House in Linear Perspective. Illustrated by 43 Folding Plates. By F. O. FERGUSON. Second Edition, Enlarged. 8vo, boards 3/6

"It is the most intelligible of the treatises on this ill-treated subject that I have met with."—E. INGRESS BELL, ESQ., in the *R.I.B.A. Journal.*

PRACTICAL RULES ON DRAWING.

For the Operative Builder and Young Student in Architecture. By GEORGE PYNE. 14 Plates, 4to, boards 7/6

MEASURING AND VALUING ARTIFICER'S WORK

(The Student's Guide to the Practice of). Containing Directions for taking Dimensions, Abstracting the same, and bringing the Quantities into Bill, with Tables of Constants for Valuation of Labour, and for the Calculation of Areas and Solidities. Originally edited by E. DOBSON, Architect. With Additions by E. W. TARN, M.A. Seventh Edition, Revised. With 8 Plates and 63 Woodcuts. Crown 8vo, cloth. [*Just Published* 7/6

"This edition will be found the most complete treatise on the principles of measuring and valuing artificer's work that has yet been published."—*Building News.*

TECHNICAL GUIDE, MEASURER, AND ESTIMATOR.

For Builders and Surveyors. Containing Technical Directions for Measuring Work in all the Building Trades, Complete Specifications for Houses, Roads, and Drains, and an Easy Method of Estimating the parts of a Building collectively. By A. C. BEATON. Eighth Edition. Waistcoat-pocket size, gilt edges 1/6

"No builder, architect, surveyor, or valuer should be without his 'Beaton.'"—*Building News.*

CONSTRUCTIONAL IRON AND STEEL WORK.

As Applied to Public, Private, and Domestic Buildings. A Practical Treatise for Architects, Students, and Builders. By F. CAMPIN. Crown 8vo, cloth. [*Just Published.* 3/6

"Any one who wants a book on ironwork, as employed in buildings for stanchions, columns, and beams, will find the present volume to be suitable. The author has had long and varied experience in designing this class of work. The illustrations have the character of working drawings. This practical book may be counted a most valuable work."—*British Architect.*

SPECIFICATIONS FOR PRACTICAL ARCHITECTURE.

A Guide to the Architect, Engineer, Surveyor, and Builder. With an Essay on the Structure and Science of Modern Buildings. Upon the Basis of the Work by ALFRED BARTHOLOMEW, thoroughly Revised, Corrected, and greatly added to by FREDERICK ROGERS, Architect. Third Edition, Revised. 8vo, cloth 15/0

"The work is too well known to need any recommendation from us. It is one of the books with which every young architect must be equipped."—*Architect.*

THE HOUSE-OWNER'S ESTIMATOR.

Or, What will it Cost to Build, Alter, or Repair? A Price Book for Unprofessional People as well as the Architectural Surveyor and Builder. By J. D. SIMON. Edited by F. T. W. MILLER, A.R.I.B.A. Fourth Edition. Crown 8vo, cloth 3/6

"In two years it will repay its cost a hundred times over."—*Field.*

SANITATION AND WATER SUPPLY.

THE PURIFICATION OF SEWAGE.

Being a Brief Account of the Scientific Principles of Sewage Purification, and their Practical Application. By SIDNEY BARWISE, M.D. (Lond.), M.R.C.S., D.P.H. (Camb.), Fellow of the Sanitary Institute, Medical Officer of Health to the Derbyshire County Council. Crown 8vo, cloth. [*Just Published.* **5/0**

"'What process shall we adopt to purify our sewage?' This question has rarely been treated from so many points of view in one book. This volume teems with practical hints, which show the intimate knowledge the author has of his subject."—*The Engineer.*

"We know of no book of the same size which gives so complete and accurate an account of the principles of sewage purification."—*The Builder.*

WATER AND ITS PURIFICATION.

A Handbook for the Use of Local Authorities, Sanitary Officers, and others interested in Water Supply. By S. RIDEAL, D.Sc. Lond., F.I.C. With numerous Illustrations and Tables. Crown 8vo, cloth. [*Just Published.* **7/6**

"Dr. Rideal's book is both interesting and accurate, and contains a most useful *résumé* of the latest knowledge upon the subject of which it treats. It ought to be of great service to all who are connected with the supply of water for domestic or manufacturing purposes."—*The Engineer.*

"Dealing as clearly as it does with the various ramifications of such an important subject as water and its purification it may be warmly recommended. Local authorities and all engaged in sanitary affairs, and others interested in water supply, will read its pages with profit."—*Lancet.*

RURAL WATER SUPPLY.

A Practical Handbook on the Supply of Water and Construction of Waterworks for Small Country Districts. By ALLAN GREENWELL, A.M.I.C.E., and W. T. CURRY, A.M.I.C.E. Revised Edition. Crown 8vo, cloth **5/0**

"We conscientiously recommend it as a very useful book for those concerned in obtaining water for small districts, giving a great deal of practical information in a small compass."—*Builder.*

THE WATER SUPPLY OF CITIES AND TOWNS.

By WILLIAM HUMBER, A.M. Inst. C.E., and M.Inst. M.E. Imp. 4to, half-bound morocco. (See page 11.) . . . . . *Net* **£6 6s.**

THE WATER SUPPLY OF TOWNS AND THE CONSTRUCTION OF WATER-WORKS.

By PROFESSOR W. K. BURTON, A.M. Inst. C.E. Second Edition, Revised and Extended. Royal 8vo, cloth. (See page 10.) **25/0**

WATER ENGINEERING.

A Practical Treatise on the Measurement, Storage, Conveyance, and Utilisation of Water for the Supply of Towns, for Mill Power, and for other Purposes. By C. SLAGG, A.M. Inst. C.E. Second Edition. Crown 8vo, cloth . **7/6**

SANITARY WORK IN SMALL TOWNS AND VILLAGES.

By CHARLES SLAGG, A. M. Inst. C.E. Crown 8vo, cloth . . . **3/0**

SANITARY ARRANGEMENT OF DWELLING-HOUSES.

A Handbook for Householders and Owners of Houses. By A. J. WALLIS-TAYLER, A.M.Inst.C.E. Crown 8vo, cloth **2/6**

"This book will be largely read; it will be of considerable service to the public. It is well arranged, easily read, and for the most part devoid of technical terms."—*Lancet.*

VENTILATION.

A Text-book to the Practice of the Art of Ventilating Buildings. By W. P. BUCHAN, R.P. Crown 8vo, cloth **3/6**

PLUMBING.

A Text-book to the Practice of the Art or Craft of the Plumber. By W. P. BUCHAN, R.P. Seventh Edition, Enlarged. Crown 8vo, cloth . . **3/6**

THE HEALTH OFFICER'S POCKET-BOOK.

A Guide to Sanitary Practice and Law. For Medical Officers of Health, Sanitary Inspectors, Members of Sanitary Authorities, &c. By EDWARD F. WILLOUGHBY, M.D. (Lond.), &c. Fcap. 8vo, cloth **7/6**

"A mine of condensed information of a pertinent and useful kind on the various subjects of which it treats. The matter seems to have been carefully compiled and arranged for facility of reference, and it is well illustrated by diagrams and woodcuts. The different subjects are succinctly but fully and scientifically dealt with."—*The Lancet.*

CARPENTRY, TIMBER, &c.

THE ELEMENTARY PRINCIPLES OF CARPENTRY.

A Treatise on the Pressure and Equilibrium of Timber Framing, the Resistance of Timber, and the Construction of Floors, Arches, Bridges, Roofs, Uniting Iron and Stone with Timber, &c. To which is added an Essay on the Nature and Properties of Timber, &c., with Descriptions of the kinds of Wood used in Building; also numerous Tables of the Scantlings of Timber for different purposes, the Specific Gravities of Materials, &c. By THOMAS TREDGOLD, C.E. With an Appendix of Specimens of Various Roofs of Iron and Stone, Illustrated. Seventh Edition, thoroughly Revised and considerably Enlarged by E. WYNDHAM TARN, M.A., Author of "The Science of Building," &c. With 61 Plates, Portrait of the Author, and several Woodcuts. In One large Vol., 4to, cloth 25/0

"Complete to be in every architect's and every builder's library."—*Builder.*

"A work whose practical excellence must ensure for it a reference whilst carpentry is concerned. The author's principles are rather confirmed than impaired by time. The additional plates are of great intrinsic value."—*Building News.*

WOODWORKING MACHINERY.

Its Rise, Progress, and Construction. With Hints on the Management of Saw Mills and the Economical Conversion of Timber. Illustrated with Examples of Recent Designs by leading English, French, and American Engineers. By M. POWIS BALE, A.M.Inst.C.E., F.R.I.M.E. Second Edition, Revised, with large Additions, large crown 8vo, 150 pp., cloth 9/0

"Mr. Bale is evidently an expert on the subject, and he has collected so much information that his book is sufficient for builders and others engaged in the conversion of timber."—*Architect.*

"The most comprehensive compendium of wood-working machinery we have seen. The author is a thorough master of his subject."—*Engineering News.*

SAW MILLS.

Their Arrangement and Management, and the Economical Conversion of Timber. By M. POWIS BALE, A.M.Inst.C.E. Second Edition, Revised. Crown 8vo, cloth. [*Just Published.* 10/6

"The subdivision of a large sawing establishment is discussed, and the subject examined from a financial standpoint. Hence the size, shape, order, and construction of saw mills and the like are gone into in detail, and the course of the timber is traced from its reception to its delivery in its converted state. We could not desire a more complete or practical treatise."—*Builder.*

THE CARPENTER'S GUIDE.

Or, Book of Lines for Carpenters: comprising all the Elementary Principles essential for acquiring a knowledge of Carpentry. Founded on the late PETER NICHOLSON'S standard work. A New Edition, Revised by ARTHUR ASHPITEL, F.S.A. Together with Practical Rules on Drawing, by GEORGE PYNE. With 74 Plates, 4to, cloth . . . . . £1 1s.

A PRACTICAL TREATISE ON HANDRAILING.

Showing New and Simple Methods for Fitting the Plank, Drawing the Moulds, Bevelling, Jointing-up, and Squaring the Wreath. By GEORGE COLLINGS. Second Edition, Revised and Enlarged, to which is added A TREATISE ON STAIR-BUILDING. With Plates and Diagrams . . 2/6

"Will be found of practical utility in the execution of this difficult branch of joinery."—*Builder.*

"Almost every difficult phase of this somewhat intricate branch of joinery is elucidated by the aid of plates and explanatory letterpress."—*Furniture Gazette.*

CIRCULAR WORK IN CARPENTRY AND JOINERY.

A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS. With Diagrams. Third Edition, 12mo, cloth . 2/6

"An excellent example of what a book of this kind should be. Cheap in price, clear in definition, and practical in the examples chosen."—*Builder.*

THE CABINET-MAKER'S GUIDE TO THE ENTIRE CONSTRUCTION OF CABINET WORK.

Including the Art of Laying Veneers, &c. By RICHARD BITMEAD. With numerous Illustrations, wrapper 3/6

HANDRAILING COMPLETE IN EIGHT LESSONS.

On the Square-Cut System. By J. S. GOLDTHORP, Head of Building Department, Halifax Technical School. With Eight Plates and over 150 Practical Exercises. 4to, cloth **3/6**

"Likely to be of considerable value to joiners and others who take a pride in good work. The arrangement of the book is excellent. We heartily commend it to teachers and students."—*Timber Trades Journal.*

TIMBER MERCHANT'S and BUILDER'S COMPANION.

Containing New and Copious Tables of the Reduced Weight and Measurement of Deals and Battens, of all sizes, from One to a Thousand Pieces, and the relative Price that each size bears per Lineal Foot to any given Price per Petersburgh Standard Hundred; the Price per Cube Foot of Square Timber to any given Price per Load of 50 Feet, &c., &c. By WILLIAM DOWSING. Fourth Edition, Revised and Corrected. Crown 8vo, cloth **3/0**

"We are glad to see a fourth edition of these admirable tables, which for correctness and simplicity of arrangement leave nothing to be desired."—*Timber Trades Journal.*

THE PRACTICAL TIMBER MERCHANT.

A Guide for the Use of Building Contractors, Surveyors, Builders, &c., containing useful Tables for all purposes connected with the Timber Trade, Marks of Wood, Essay on the Strength of Timber, Remarks on the Growth of Timber, &c. By W. RICHARDSON. Second Edition. Fcap. 8vo, cloth . **3/6**

"Contains much valuable information for timber merchants, builders, foresters, and all others connected with the growth, sale, and manufacture of timber."—*Journal of Forestry.*

PACKING-CASE TABLES.

Showing the number of Superficial Feet in Boxes or Packing-Cases, from six inches square and upwards. By W. RICHARDSON, Timber Broker. Third Edition. Oblong 4to, cloth **3/6**

"Invaluable labour saving tables."—*Ironmonger.*

GUIDE TO SUPERFICIAL MEASUREMENT.

Tables calculated from 1 to 200 inches in length by 1 to 108 inches in breadth. For the use of Architects, Surveyors, Engineers, Timber Merchants, Builders, &c. By JAMES HAWKINGS. Fourth Edition. Fcap., cloth. **3/6**

"A useful collection of tables to facilitate rapid calculation of surfaces. The exact area of any surface of which the limits have been ascertained can be instantly determined. The book will be found of the greatest utility to all engaged in building operations."—*Scotsman.*

PRACTICAL FORESTRY.

And its Bearing on the Improvement of Estates. By CHARLES E. CURTIS, F.S.I., Professor of Forestry, Field Engineering, and General Estate Management at the College of Agriculture, Downton. Second Edition, Revised. Crown 8vo, cloth. [*Just Published.* **3/6**

SUMMARY OF CONTENTS.—PRELATORY REMARKS—OBJECTS OF PLANTING—CHOICE OF A FORESTER—CHOICE OF SOIL AND SITE—LAYING OUT OF LAND FOR PLANTATIONS—PREPARATION OF THE GROUND FOR PLANTING—DRAINAGE—PLANTING—DISTANCES AND DIRECTION OF TREES IN PLANTATIONS—TREES AND GROUND GAME—ATTENTION AFTER PLANTING—THINNING OF PLANTATIONS—PRUNING OF FOREST TREES—REALIZATION—METHODS OF SALE—MEASUREMENT OF TIMBER—MEASUREMENT AND VALUATION OF LARCH PLANTATION—FIRE LINES—COST OF PLANTING.

"Mr. Curtis has in the course of a series of short pithy chapters afforded much information of a useful and practical character on the planting and subsequent treatment of trees."—*Illustrated Carpenter and Builder.*

THE ELEMENTS OF FORESTRY.

Designed to afford Information concerning the Planting and Care of Forest Trees for Ornament or Profit, with suggestions upon the Creation and Care of Woodlands. By F. B. HOUGH. Large crown 8vo, cloth **10/0**

THE TIMBER IMPORTER'S, TIMBER MERCHANT'S, AND BUILDER'S STANDARD GUIDE.

By RICHARD E. GRANDY. Comprising:—An Analysis of Deal Standards, Home and Foreign, with Comparative Values and Tabular Arrangements for fixing Net Landed Cost on Baltic and North American Deals, including all intermediate Expenses, Freight, Insurance, &c.; together with copious Information for the Retailer and Builder. Third Edition. 12mo, cloth . . . **2/**

DECORATIVE ARTS, &c.

SCHOOL OF PAINTING FOR THE IMITATION OF WOODS AND MARBLES.

As Taught and Practised by A. R. VAN DER BURG and P. VAN DER BURG, Directors of the Rotterdam Painting Institution. Royal folio, 18½ by 12½ in., Illustrated with 24 full-size Coloured Plates; also 12 plain Plates, comprising 154 Figures. Third Edition, cloth. *[Just Published.* £1 11s. 6d.

LIST OF PLATES:—1. VARIOUS TOOLS REQUIRED FOR WOOD PAINTING.—2, 3. WALNUT; PRELIMINARY STAGES OF GRAINING AND FINISHED SPECIMEN.—4. TOOLS USED FOR MARBLE PAINTING AND METHOD OF MANIPULATION.—5, 6. ST. REMI MARBLE; EARLIER OPERATIONS AND FINISHED SPECIMEN. — 7. METHODS OF SKETCHING DIFFERENT GRAINS, KNOTS, &c.—8, 9. ASH: PRELIMINARY STAGES AND FINISHED SPECIMEN.—10. METHODS OF SKETCHING MARBLE GRAINS.—11, 12. BRECHE MARBLE; PRELIMINARY STAGES OF WORKING AND FINISHED SPECIMEN.—13. MAPLE: METHODS OF PRODUCING THE DIFFERENT GRAINS.—14, 15. BIRD'S-EYE MAPLE: PRELIMINARY STAGES AND FINISHED SPECIMEN.—16. METHODS OF SKETCHING THE DIFFERENT SPECIES OF WHITE MARBLE.—17, 18. WHITE MARBLE; PRELIMINARY STAGES OF PROCESS AND FINISHED SPECIMEN.—19. MAHOGANY: SPECIMENS OF VARIOUS GRAINS AND METHODS OF MANIPULATION.—20, 21. MAHOGANY; EARLIER STAGES AND FINISHED SPECIMEN.—22, 23, 24. SIENNA MARBLE; VARIETIES OF GRAIN, PRELIMINARY STAGES AND FINISHED SPECIMEN.—25, 26, 27. JUNIPER WOOD: METHODS OF PRODUCING GRAIN, &c.; PRELIMINARY STAGES AND FINISHED SPECIMEN.—28, 29, 30. VERT DE MER MARBLE: VARIETIES OF GRAIN AND METHODS OF WORKING, UNFINISHED AND FINISHED SPECIMENS.—31, 32, 33. OAK: VARIETIES OF GRAIN, TOOLS EMPLOYED AND METHODS OF MANIPULATION, PRELIMINARY STAGES AND FINISHED SPECIMEN.—34, 35, 36. WAULSORT MARBLE; VARIETIES OF GRAIN, UNFINISHED AND FINISHED SPECIMENS.

"Those who desire to attain skill in the art of painting woods and marbles will find advantage in consulting this book. . . . Some of the Working Men's Clubs should give their young men the opportunity to study it."—*Builder.*

"A comprehensive guide to the art. The explanations of the processes, the manipulation and management of the colours, and the beautifully executed plates will not be the least valuable to the student who aims at making his work a faithful transcript of nature."—*Building News.*

"Students and novices are fortunate who are able to become the possessors of so noble a work."—*The Architect.*

ELEMENTARY DECORATION.

A Guide to the Simpler Forms of Everyday Art. Together with PRACTICAL HOUSE DECORATION. By JAMES W. FACEY. With numerous Illustrations. In One Vol., strongly half-bound 5/0

HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING.

A Practical Manual of. By ELLIS A. DAVIDSON. Seventh Edition. With Coloured Plates and Wood Engravings. 12mo, cloth boards . . . 6/0

"A mass of information of use to the amateur and of value to the practical man."—*English Mechanic.*

THE DECORATOR'S ASSISTANT.

A Modern Guide for Decorative Artists and Amateurs, Painters, Writers, Gilders, &c. Containing upwards of 600 Receipts, Rules, and Instructions; with a variety of Information for General Work connected with every Class of Interior and Exterior Decorations, &c. Seventh Edition. 152 pp., cr. 8vo. 1/0

"Full of receipts of value to decorators, painters, gilders, &c. The book contains the gist of larger treatises on colour and technical processes. It would be difficult to meet with a work so full of varied information on the painter's art."—*Building News.*

MARBLE DECORATION

And the Terminology of British and Foreign Marbles. A Handbook for Students. By GEORGE H. BLAGROVE, Author of "Shoring and its Application," &c. With 28 Illustrations. Crown 8vo, cloth 3/6

"This most useful and much wanted handbook should be in the hands of every architect and builder."—*Building World.*

"A carefully and usefully written treatise; the work is essentially practical."—*Scotsman.*

DELAMOTTE'S WORKS ON ALPHABETS AND ILLUMINATION.

ORNAMENTAL ALPHABETS, ANCIENT & MEDIÆVAL.

From the Eighth Century, with Numerals; including Gothic, Church-Text, large and small, German, Italian, Arabesque, Initials for Illumination, Monograms, Crosses, &c., &c., for the use of Architectural and Engineering Draughtsmen, Missal Painters, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c., &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, ornamental boards **2/6**

"For those who insert enamelled sentences round gilded chalices, who blazon shop legends over shop-doors, who letter church walls with pithy sentences from the Decalogue, this book will be useful."—*Athenæum.*

MODERN ALPHABETS, PLAIN AND ORNAMENTAL.

Including German, Old English, Saxon, Italic, Perspective, Greek, Hebrew, Court Hand, Engrossing, Tuscan, Riband, Gothic, Rustic, and Arabesque; with several Original Designs, and an Analysis of the Roman and Old English Alphabets, large and small, and Numerals, for the use of Draughtsmen, Surveyors, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, ornamental boards . **2/6**

"There is comprised in it every possible shape into which the letters of the alphabet and numerals can be formed, and the talent which has been expended in the conception of the various plain and ornamental letters is wonderful."—*Standard.*

MEDIÆVAL ALPHABETS AND INITIALS FOR ILLUMINATORS.

By F. G. DELAMOTTE. Containing 21 Plates and Illuminated Title, printed in Gold and Colours. With an Introduction by J. WILLIS BROOKS. Fourth and Cheaper Edition. Small 4to, ornamental boards **4/0**

"A volume in which the letters of the alphabet come forth glorified in gilding and all the colours of the prism interwoven and intertwined and intermingled."—*Sun.*

A PRIMER OF THE ART OF ILLUMINATION.

For the Use of Beginners; with a Rudimentary Treatise on the Art, Practical Directions for its Exercise, and Examples taken from Illuminated MSS., printed in Gold and Colours. By F. DELAMOTTE. New and Cheaper Edition. Small 4to, ornamental boards **6/0**

"The examples of ancient MSS. recommended to the student, which, with much good sense, the author chooses from collections accessible to all, are selected with judgment and knowledge as well as taste."—*Athenæum.*

THE EMBROIDERER'S BOOK OF DESIGN.

Containing Initials, Emblems, Cyphers, Monograms, Ornamental Borders, Ecclesiastical Devices, Mediæval and Modern Alphabets, and National Emblems. Collected by F. DELAMOTTE, and printed in Colours. Oblong royal 8vo, ornamental wrapper **1/6**

"The book will be of great assistance to ladies and young children who are endowed with the art of plying the needle in this most ornamental and useful pretty work."—*East Anglian Times*

INSTRUCTIONS IN WOOD-CARVING FOR AMATEURS.

With Hints on Design. By A LADY. With 10 Plates. New and Cheaper Edition. Crown 8vo, in emblematic wrapper **2/0**

"The handicraft of the wood carver, so well as a book can impart it, may be learnt from 'A Lady's' publication."—*Athenæum.*

PAINTING POPULARLY EXPLAINED.

By THOMAS JOHN GULLICK, Painter, and JOHN TIMBS, F.S.A. Including Fresco, Oil, Mosaic, Water-Colour, Water-Glass, Tempera, Encaustic, Miniature, Painting on Ivory, Vellum, Pottery, Enamel, Glass, &c. Fifth Edition. Crown 8vo, cloth **6/0**

*** *Adopted as a Prize Book at South Kensington.*

"Much may be learned, even by those who fancy they do not require to be taught, from the careful perusal of this unpretending but comprehensive treatise."—*Art Journal.*

NATURAL SCIENCE, &c.

THE VISIBLE UNIVERSE.

Chapters on the Origin and Construction of the Heavens. By J. E. GORE, F.R.A.S., Author of "Star Groups," &c. Illustrated by 6 Stellar Photographs and 12 Plates. Demy 8vo, cloth 16/0

"A valuable and lucid summary of recent astronomical theory, rendered more valuable and attractive by a series of stellar photographs and other illustrations."—*The Times.*

"In presenting a clear and concise account of the present state of our knowledge Mr. Gore has made a valuable addition to the literature of the subject."—*Nature.*

"Mr. Gore's 'Visible Universe' is one of the finest works on astronomical science that have recently appeared in our language. In spirit and in method it is scientific from cover to cover, but the style is so clear and attractive that it will be as acceptable and as readable to those who make no scientific pretensions as to those who devote themselves specially to matters astronomical."—*Leeds Mercury.*

STAR GROUPS.

A Student's Guide to the Constellations. By J. ELLARD GORE, F.R.A.S., M.R.I.A., &c., Author of "The Visible Universe," "The Scenery of the Heavens," &c. With 30 Maps. Small 4to, cloth 5/0

"The volume contains thirty maps showing stars of the sixth magnitude—the usual naked-eye limit—and each is accompanied by a brief commentary adapted to facilitate recognition and bring to notice objects of special interest. For the purpose of a preliminary survey of the 'midnight pomp' of the heavens nothing could be better than a set of delineations averaging scarcely twenty square inches in area and including nothing that cannot at once be identified."—*Saturday Review.*

AN ASTRONOMICAL GLOSSARY.

Or, Dictionary of Terms used in Astronomy. With Tables of Data and Lists of Remarkable and Interesting Celestial Objects. By J. ELLARD GORE, F.R.A.S., Author of "The Visible Universe," &c. Small crown 8vo, cloth. 2/6

"A very useful little work for beginners in astronomy, and not to be despised by more advanced students."—*The Times.*

"A very handy book . . . the utility of which is much increased by its valuable tables of astronomical data."—*Athenæum*

THE MICROSCOPE.

Its Construction and Management. Including Technique, Photo-micrography, and the Past and Future of the Microscope. By Dr. HENRI VAN HEURCK. Re-Edited and Augmented from the Fourth French Edition, and Translated by WYNNE E. BAXTER, F.G.S. 400 pp., with upwards of 250 Woodcuts, Imp. 8vo, cloth 16/0

"A translation of a well-known work, at once popular and comprehensive."—*Times.*

"The translation is as felicitous as it is accurate."—*Nature.*

ASTRONOMY.

By the late Rev. ROBERT MAIN, M.A., F.R.S. Third Edition, Revised by WILLIAM THYNNE LYNN, B.A., F.R.A.S., formerly of the Royal Observatory, Greenwich. 12mo, cloth 2/0

"A sound and simple treatise, very carefully edited, and a capital book for beginners."—*Knowledge.*

"Accurately brought down to the requirements of the present time by Mr. Lynn."—*Educational Times.*

A MANUAL OF THE MOLLUSCA.

A Treatise on Recent and Fossil Shells. By S. P. WOODWARD, A.L.S., F.G.S. With an Appendix on RECENT AND FOSSIL CONCHOLOGICAL DISCOVERIES, by RALPH TATE, A.L.S., F.G.S. With 23 Plates and upwards of 300 Woodcuts. Reprint of Fourth Edition (1880). Crown 8vo, cloth 7/6

"A most valuable storehouse of conchological and geological information."—*Science Gossip.*

THE TWIN RECORDS OF CREATION.

Or, Geology and Genesis, their Perfect Harmony and Wonderful Concord. By G. W. V. LE VAUX. 8vo. cloth 5/0

"A valuable contribution to the evidences of Revelation, and disposes very conclusively of the arguments of those who would set God's Works against God's Word. No real difficulty is shirked and no sophistry is left unexposed."—*The Rock.*

HANDBOOK OF MECHANICS.

By Dr. LARDNER. Enlarged and re-written by BENJAMIN LOEWY, F.R.A.S. 378 Illustrations. Post 8vo, cloth **6/0**

"The perspicuity of the original has been retained, and chapters which had become obsolete have been replaced by others of more modern character. The explanations throughout are studiously popular, and care has been taken to show the application of the various branches of physics to the industrial arts, and to the practical business of life."—*Mining Journal.*

HANDBOOK OF HYDROSTATICS AND PNEUMATICS.

By Dr. LARDNER. New Edition, Revised and Enlarged by BENJAMIN LOEWY, F.R.A.S. With 236 Illustrations. Post 8vo, cloth **5/0**

"For those 'who desire to attain an accurate knowledge of physical science without the profound methods of mathematical investigation,' this work is well adapted."—*Chemical News.*

HANDBOOK OF HEAT.

By Dr. LARDNER. Edited and re-written by BENJAMIN LOEWY, F.R.A.S., &c. 117 Illustrations. Post 8vo, cloth **6/0**

"The style is always clear and precise, and conveys instruction without leaving any cloudiness or lurking doubts behind."—*Engineering.*

HANDBOOK OF OPTICS.

By Dr. LARDNER. New Edition. Edited by T. OLVER HARDING, B.A. Lond. With 298 Illustrations. Small 8vo, 448 pp., cloth **5/0**

"Written by one of the ablest English scientific writers, beautifully and elaborately illustrated."—*Mechanics Magazine.*

ELECTRICITY, MAGNETISM, AND ACOUSTICS.

By Dr. LARDNER. Edited by GEO. CAREY FOSTER, B.A., F.C.S. With 400 Illustrations. Small 8vo, cloth **5/0**

"The book could not have been entrusted to any one better calculated to preserve the terse and lucid style of Lardner, while correcting his errors and bringing up his work to the present standard of scientific knowledge."—*Popular Science Review.*

HANDBOOK OF ASTRONOMY.

By Dr. LARDNER. Fourth Edition. Revised and Edited by EDWIN DUNKIN, F.R.A.S., Royal Observatory, Greenwich. With 38 Plates and upwards of 100 Woodcuts. 8vo, cloth **9/6**

"Probably no other book contains the same amount of information in so compendious and well arranged a form—certainly none at the price at which this is offered to the public."—*Athenæum.*

"We can do no other than pronounce this work a most valuable manual of astronomy, and we strongly recommend it to all who wish to acquire a general—but at the same time correct—acquaintance with this sublime science."—*Quarterly Journal of Science.*

MUSEUM OF SCIENCE AND ART.

Edited by Dr. LARDNER. With upwards of 1,200 Engravings on Wood. In Six Double Volumes, **£1 1s.** in a new and elegant cloth binding; or handsomely bound in half-morocco . . . . . **£1 11s. 6d.**

"A cheap and interesting publication, alike informing and attractive. The papers combine subjects of importance and great scientific knowledge, considerable inductive powers, and a popular style of treatment."—*Spectator.*

Separate books formed from the above.

Common Things Explained. 5s.
The Microscope. 2s. cloth.
Popular Geology. 2s. 6d. cloth.
Popular Physics. 2s. 6d. cloth.
Steam and its Uses. 2s. cloth.
Popular Astronomy. 4s. 6d. cloth.
The Bee and White Ants. 2s. cloth.
The Electric Telegraph. 1s. 6d.

NATURAL PHILOSOPHY FOR SCHOOLS.

By Dr. LARDNER. Fcap. 8vo **3/6**

"A very convenient class book for junior students in private schools."—*British Quarterly Review.*

ANIMAL PHYSIOLOGY FOR SCHOOLS.

By Dr. LARDNER. Fcap. 8vo **3/6**

"Clearly written, well arranged, and excellently illustrated."—*Gardener's Chronicle.*

THE ELECTRIC TELEGRAPH.

By Dr. LARDNER. Revised by E. B. BRIGHT, F.R.A.S. Fcap. 8vo. . **2/6**

One of the most readable books extant on the Electric Telegraph."—*English Mechanic.*

CHEMICAL MANUFACTURES, CHEMISTRY, &c.

THE GAS ENGINEER'S POCKET-BOOK.

Comprising Tables, Notes and Memoranda relating to the Manufacture, Distribution and Use of Coal Gas and the Construction of Gas Works. By H. O'CONNOR, A.M.Inst.C.E., 450 pp., crown 8vo, fully Illustrated, leather. [*Just Published.* 10/6

"The book contains a vast amount of information. The author goes consecutively through the engineering details and practical methods involved in each of the different processes or parts of a gas-works. He has certainly succeeded in making a compilation of hard matters of fact absolutely interesting to read."—*Gas World.*

"A useful work of reference for the gas engineer and all interested in lighting or heating by gas, while the analyses of the various descriptions of gas will be of value to the technical chemist. All matter in any way connected with the manufacture and use of gas is dealt with. The book has evidently been carefully compiled, and certainly constitutes a useful addition to gas literature."—*Builder.*

"The volume contains a great quantity of useful information, compiled, we believe, from trustworthy sources, which should make it of considerable value to those for whom it is specially produced."—*Engineer.*

LIGHTING BY ACETYLENE

Generators, Burners, and Electric Furnaces. By WILLIAM E. GIBBS, M.E. With 86 Illustrations. Crown 8vo, cloth. [*Just Published.* 7/6

ENGINEERING CHEMISTRY.

A Practical Treatise for the Use of Analytical Chemists, Engineers, Iron Masters, Iron Founders, Students and others. Comprising Methods of Analysis and Valuation of the Principal Materials used in Engineering Work, with Analyses, Examples and Suggestions. By H. J. PHILLIPS, F.I.C., F.C.S. Second Edition, Enlarged. Crown 8vo, 400 pp., with Illustrations, cloth 10/6

"In this work the author has rendered no small service to a numerous body of practical men. . . . The analytical methods may be pronounced most satisfactory, being as accurate as the despatch required of engineering chemists permits."—*Chemical News.*

"Full of good things. As a handbook of technical analysis it is very welcome."—*Builder.*

"The analytical methods given are, as a whole, such as are likely to give rapid and trustworthy results in experienced hands. . . . There is much excellent descriptive matter in the work, the chapter on 'Oils and Lubrication' being specially noticeable in this respect."—*Engineer.*

NITRO-EXPLOSIVES.

A Practical Treatise concerning the Properties, Manufacture, and Analysis of Nitrated Substances, including the Fulminates, Smokeless Powders, and Celluloid. By P. G. SANFORD, F.I.C., Consulting Chemist to the Cotton Powder Company, &c. With Illustrations. Crown 8vo, cloth. [*Just Published.* 9/0

"Any one having the requisite apparatus and materials could make nitro-glycerine or gun-cotton, to say nothing of other explosives, by the aid of the instructions in this volume. This is one of the very few text-books in which can be found just what is wanted. Mr. Sanford goes through the whole list of explosives commonly used, names any patent explosive, and tells us of what it is composed and how it is manufactured. The book is excellent throughout."—*Iron Trade.*

A HANDBOOK ON MODERN EXPLOSIVES.

A Practical Treatise on the Manufacture and Use of Dynamite, Gun-Cotton, Nitro-Glycerine and other Explosive Compounds, including Collodion-Cotton. With Chapters on Explosives in Practical Application. By M. EISSLER, Mining Engineer and Metallurgical Chemist. Second Edition, Enlarged. With 150 Illustrations. Crown 8vo, cloth. [*Just Published.* 12/6

"Useful not only to the miner, but also to officers of both services to whom blasting and the use of explosives generally may at any time become a necessary auxiliary."—*Nature.*

DANGEROUS GOODS.

Their Sources and Properties, Modes of Storage and Transport. With Notes and Comments on Accidents arising therefrom, together with the Government and Railway Classifications, Acts of Parliament, &c. A Guide for the Use of Government and Railway Officials, Steamship Owners, Insurance Companies and Manufacturers, and Users of Explosives and Dangerous Goods. By H. JOSHUA PHILLIPS, F.I.C., F.C.S. Crown 8vo, 274 pp., cloth . . 9/0

"Merits a wide circulation, and an intelligent appreciative study."—*Chemical News.*

A MANUAL OF THE ALKALI TRADE.

Including the Manufacture of Sulphuric Acid, Sulphate of Soda, and Bleaching Powder. By JOHN LOMAS, Alkali Manufacturer, Newcastle-upon-Tyne and London. 300 pp. of Text. With 232 Illustrations and Working Drawings, Second Edition, with Additions. Super-royal 8vo, cloth . . **£1 10s.**

"This book is written by a manufacturer for manufacturers. The working details of the most approved forms of apparatus are given, and these are accompanied by no less than 232 wood engravings, all of which may be used for the purposes of construction. Every step in the manufacture is very fully described in this manual, and each improvement explained."—*Athenæum*.

"We find not merely a sound and luminous explanation of the chemical principles of the trade, but a practice of numerous matters which have a most important bearing on the successful conduct of alkali works, but which are generally overlooked by even experienced technological authors."—*Chemical Review*.

THE BLOWPIPE IN CHEMISTRY, MINERALOGY, AND GEOLOGY.

Containing all known Methods of Anhydrous Analysis, many Working Examples, and Instructions for Making Apparatus. By Lieut.-Colonel W. A. Ross, R.A., F.G.S. With 120 Illustrations. Second Edition, Enlarged. Crown 8vo, cloth **5/0**

"The student who goes conscientiously through the course of experimentation here laid down will gain a better insight into inorganic chemistry and mineralogy than if he had 'got up' any of the best text-books of the day, and passed any number of examinations in their contents."—*Chemical News*.

THE MANUAL OF COLOURS AND DYE-WARES.

Their Properties, Applications, Valuations, Impurities and Sophistications. For the Use of Dyers, Printers, Drysalters, Brokers, &c. By J. W. SLATER. Second Edition, Revised and greatly Enlarged. Crown 8vo, cloth . **7/6**

"A complete encyclopædia of the *materia tinctoria*. The information given respecting each article is full and precise, and the methods of determining the value of articles such as these, so liable to sophistication, are given with clearness, and are practical as well as valuable."—*Chemist and Druggist*.

"There is no other work which covers precisely the same ground. To students preparing for examinations in dyeing and printing it will prove exceedingly useful."—*Chemical News*.

A HANDY BOOK FOR BREWERS.

Being a Practical Guide to the Art of Brewing and Malting. Embracing the Conclusions of Modern Research which bear upon the Practice of Brewing. By HERBERT EDWARDS WRIGHT, M.A. Second Edition, Enlarged. Crown 8vo, 530 pp., cloth. [*Just Published.* **12/6**

"May be consulted with advantage by the student who is preparing himself for examinational tests, while the scientific brewer will find in it a *résumé* of all the most important discoveries of modern times. The work is written throughout in a clear and concise manner, and the author takes great care to discriminate between vague theories and well-established facts."—*Brewers' Journal*.

"We have great pleasure in recommending this handy book, and have no hesitation in saying that it is one of the best—if not the best—which has yet been written on the subject of beer brewing in this country; it should have a place on the shelves of every brewer's library."—*Brewers' Guardian*.

"Although the requirements of the student are primarily considered, an acquaintance of half-an-hour's duration cannot fail to impress the practical brewer with the sense of having found a trustworthy guide and practical counsellor in brewery matters."—*Chemical Trade Journal*.

FUELS: SOLID, LIQUID, AND GASEOUS.

Their Analysis and Valuation. For the Use of Chemists and Engineers. By H. J. PHILLIPS, F.C.S., formerly Analytical and Consulting Chemist to the G.E. Rlwy. Third Edition, Revised and Enlarged. Crown 8vo, cloth **2/0**

"Ought to have its place in the laboratory of every metallurgical establishment and wherever fuel is used on a large scale."—*Chemical News*.

THE ARTISTS' MANUAL OF PIGMENTS.

Showing their Composition, Conditions of Permanency, Non-Permanency, and Adulterations; Effects in Combination with Each Other and with Vehicles; and the most Reliable Tests of Purity. By H. C. STANDAGE. crown 8vo. 2/6

"This work is indeed *multum-in-parvo*, and we can, with good conscience, recommend it to all who come in contact with pigments, whether as makers, dealers, or users."—*Chemical Review.*

A POCKET-BOOK OF MENSURATION AND GAUGING.

Containing Tables, Rules, and Memoranda for Revenue Officers, Brewers, Spirit Merchants, &c. By J. B. MANT, Inland Revenue. Second Edition, Revised. 18mo, leather 4/0

"This handy and useful book is adapted to the requirements of the Inland Revenue Department, and will be a favourite book of reference."—*Civilian.*

"Should be in the hands of every practical brewer."—*Brewers' Journal.*

INDUSTRIAL ARTS, TRADES, AND MANUFACTURES.

MODERN CYCLES.

A Practical Handbook on their Construction and Repair. By A. J. WALLIS-TAYLER, A. M. Inst. C. E. Author of "Refrigerating Machinery," &c. With upwards of 300 Illustrations. Crown 8vo. cloth. [*Just Published.* 10/6

"The large trade that is done in the component parts of bicycles has placed in the way of men mechanically inclined extraordinary facilities for building bicycles for their own use . . The book will prove a valuable guide for all those who aspire to the manufacture or repair of their own machines."—*The Field.*

"A most comprehensive and up-to-date treatise."—*The Cycle.*

"A very useful book, which is quite entitled to rank as a standard work for students of cycle construction."—*Wheeling.*

TEA MACHINERY AND TEA FACTORIES.

A Descriptive Treatise on the Mechanical Appliances required on Tea Plantations in the Preparation of Tea for the Market. By A. J. W. TAYLER, A.M. Inst. C.E. With about 200 Illustrations. Medium 8vo.

[*Nearly Ready. Price, about* 25/0

TEA PLANTING AND MANUFACTURE

(A Text Book of). Comprising Chapters on the History and Development of the Industry, the Cultivation of the Plant, the Preparation of the Leaf for the Market, &c. By DAVID CROLE, late of the Jokai Tea Company, &c. With Plates and other Illustrations. Medium 8vo, cloth 16/0

COTTON MANUFACTURE.

A Manual of Practical Instruction of the Processes of Opening, Carding, Combing, Drawing, Doubling and Spinning of Cotton, the Methods of Dyeing, &c. For the Use of Operatives, Overlookers, and Manufacturers. By JOHN LISTER, Technical Instructor, Pendleton. 8vo. cloth . . 7/6

"A distinct advance in the literature of cotton manufacture."—*Machinery.*

"It is thoroughly reliable, fulfilling nearly all the requirements desired."—*Glasgow Herald.*

FLOUR MANUFACTURE.

A Treatise on Milling Science and Practice. By FRIEDRICH KICK, Imperial Regierungsrath, Professor of Mechanical Technology in the Imperial German Polytechnic Institute, Prague. Translated from the Second Enlarged and Revised Edition with Supplement. By H. H. P. POWLES, Assoc. Memb. Institution of Civil Engineers. Nearly 400 pp. Illustrated with 28 Folding Plates, and 167 Woodcuts. Royal 8vo, cloth . . . . . £1 5s.

"This valuable work is, and will remain, the standard authority on the science of milling. . . . The miller who has read and digested this work will have laid the foundation, so to speak, of a successful career; he will have acquired a number of general principles which he can proceed to apply. In this handsome volume we at last have the accepted text-book of modern milling in good, sound English, which has little, if any, trace of the German idiom."—*The Miller.*

CEMENTS, PASTES, GLUES, AND GUMS.

A Practical Guide to the Manufacture and Application of the various Agglutinants required in the Building, Metal-Working, Wood-Working, and Leather-Working Trades, and for Workshop, Laboratory or Office Use. With upwards of 1000 Recipes and Formulæ. By H. C. STANDAGE, Chemist. Third Edition. Crown 8vo, cloth. [*Just Published.* **2/0**

"We have pleasure in speaking favourably of this volume. So far as we have had experience which is not inconsiderable, this manual is trustworthy."—*Athenæum.*

"As a revelation of what are considered trade secrets, this book will arouse an amount of curiosity among the large number of industries it touches."—*Daily Chronicle.*

THE ART OF SOAP-MAKING.

A Practical Handbook of the Manufacture of Hard and Soft Soaps, Toilet Soaps, &c. Including many New Processes, and a Chapter on the Recovery of Glycerine from Waste Leys. By ALEX. WATT. Fifth Edition, Revised, with an Appendix on Modern Candlemaking. Crown 8vo, cloth . . . **7/6**

"The work will prove very useful, not merely to the technological student, but to the practical soap boiler who wishes to understand the theory of his art."—*Chemical News.*

"A thoroughly practical treatise on an art which has almost no literature in our language. We congratulate the author on the success of his endeavour to fill a void in English technical literature."—*Nature.*

PRACTICAL PAPER-MAKING.

A Manual for Paper-Makers and Owners and Managers of Paper-Mills. With Tables, Calculations, &c. By G. CLAPPERTON, Paper-Maker. With Illustrations of Fibres from Micro-Photographs. Crown 8vo, cloth . . **5/0**

"The author caters for the requirements of responsible mill hands, apprentices, &c., whilst his manual will be found of great service to students of technology, as well as to veteran paper-makers and mill owners. The illustrations form an excellent feature."—*The World's Paper Trade Review.*

"We recommend everybody interested in the trade to get a copy of this thoroughly practical book."—*Paper Making.*

THE ART OF PAPER-MAKING.

A Practical Handbook of the Manufacture of Paper from Rags, Esparto, Straw, and other Fibrous Materials. Including the Manufacture of Pulp from Wood Fibre, with a Description of the Machinery and Appliances used. To which are added Details of Processes for Recovering Soda from Waste Liquors. By ALEXANDER WATT, Author of "The Art of Soap-Making." With Illustrations. Crown 8vo, cloth **7/6**

"It may be regarded as the standard work on the subject. The book is full of valuable information. The 'Art of Paper-Making' is in every respect a model of a text-book, either for a technical class, or for the private student."—*Paper and Printing Trades Journal.*

A TREATISE ON PAPER

For Printers and Stationers. With an Outline of Paper Manufacture; Complete Tables of Sizes, and Specimens of Different Kinds of Paper. By RICHARD PARKINSON, late of the Manchester Technical School. Demy 8vo, cloth. [*Just Published.* **3/6**

THE ART OF LEATHER MANUFACTURE.

Being a Practical Handbook, in which the Operations of Tanning, Currying, and Leather Dressing are fully Described, and the Principles of Tanning Explained, and many Recent Processes Introduced; as also Methods for the Estimation of Tannin, and a Description of the Arts of Glue Boiling, Gut Dressing, &c. By ALEXANDER WATT, Author of "Soap-Making," &c. Fourth Edition. Crown 8vo, cloth **9/0**

"A sound, comprehensive treatise on tanning and its accessories. The book is an eminently valuable production, which redounds to the credit of both author and publishers."—*Chemical Review.*

THE ART OF BOOT AND SHOE MAKING.

A Practical Handbook, including Measurement, Last-Fitting, Cutting-Out, Closing and Making, with a Description of the most approved Machinery Employed. By JOHN B. LENO, late Editor of *St. Crispin*, and *The Boot and Shoe-Maker.* 12mo, cloth **2/0**

WOOD ENGRAVING.

A Practical and Easy Introduction to the Study of the Art. By W. N. BROWN. 12mo, cloth 1/6

"The book is clear and complete, and will be useful to any one wanting to understand the first elements of the beautiful art of wood engraving."—*Graphic.*

MODERN HOROLOGY, IN THEORY AND PRACTICE.

Translated from the French of CLAUDIUS SAUNIER, ex-Director of the School of Horology at Macon, by JULIEN TRIPPLIN, F.R.A.S., Besancon Watch Manufacturer, and EDWARD RIGG, M.A., Assayer in the Royal Mint. With Seventy-eight Woodcuts and Twenty-two Coloured Copper Plates. Second Edition. Super-royal 8vo, cloth, £2 2s.; half-calf . . . £2 10s.

"There is no horological work in the English language at all to be compared to this production of M. Saunier's for clearness and completeness. It is alike good as a guide for the student and as a reference for the experienced horologist and skilled workman."—*Horological Journal.*

"The latest, the most complete, and the most reliable of those literary productions to which continental watchmakers are indebted for the mechanical superiority over their English brethren—in fact, the Book of Books, is M. Saunier's 'Treatise.'"—*Watchmaker, Jeweller, and Silversmith.*

THE WATCH ADJUSTER'S MANUAL.

A Practical Guide for the Watch and Chronometer Adjuster in Making, Springing, Timing and Adjusting for Isochronism, Positions and Temperatures. By C. E. FRITTS. 370 pp., with Illustrations, 8vo, cloth . . . 16/0

THE WATCHMAKER'S HANDBOOK.

Intended as a Workshop Companion for those engaged in Watchmaking and the Allied Mechanical Arts. Translated from the French of CLAUDIUS SAUNIER, and enlarged by JULIEN TRIPPLIN, F.R.A.S., and EDWARD RIGG, M.A., Assayer in the Royal Mint. Third Edition. 8vo, cloth. 12/0

"Each part is truly a treatise in itself. The arrangement is good and the language is clear and concise. It is an admirable guide for the young watchmaker."—*Engineering.*

"It is impossible to speak too highly of its excellence. It fulfils every requirement in a handbook intended for the use of a workman. Should be found in every workshop."—*Watch and Clockmaker.*

A HISTORY OF WATCHES & OTHER TIMEKEEPERS.

By JAMES F. KENDAL, M.B.H. Inst. Boards, 1/6; or cloth, gilt . 2/6

"The best which has yet appeared on this subject in the English language."—*Industries.*

"Open the book where you may, there is interesting matter in it concerning the ingenious devices of the ancient or modern horologer."—*Saturday Review.*

ELECTRO-DEPOSITION.

A Practical Treatise on the Electrolysis of Gold, Silver, Copper, Nickel, and other Metals and Alloys. With Descriptions of Voltaic Batteries, Magneto and Dynamo-Electric Machines, Thermopiles, and of the Materials and Processes used in every Department of the Art, and several Chapters on ELECTRO-METALLURGY. By ALEXANDER WATT, Author of "Electro-Metallurgy," &c. Third Edition, Revised. Crown 8vo, cloth . . 9/0

"Eminently a book for the practical worker in electro-deposition. It contains practical descriptions of methods, processes and materials, as actually pursued and used in the workshop."—*Engineer.*

ELECTRO-METALLURGY.

Practically Treated. By ALEXANDER WATT. Tenth Edition, including the most recent Processes. 12mo, cloth 3/6

"From this book both amateur and artisan may learn everything necessary for the successful prosecution of electroplating."—*Iron.*

JEWELLER'S ASSISTANT IN WORKING IN GOLD.

A Practical Treatise for Masters and Workmen, Compiled from the Experience of Thirty Years' Workshop Practice. By GEORGE E. GEE, Author of "The Goldsmith's Handbook," &c. Crown 8vo, cloth 7/6

"This manual of technical education is apparently destined to be a valuable auxiliary to a handicraft which is certainly capable of great improvement."—*The Times.*

ELECTROPLATING.

A Practical Handbook on the Deposition of Copper, Silver, Nickel, Gold, Aluminium, Brass, Platinum, &c., &c. By J. W. URQUHART, C.E. Fourth Edition, Revised. Crown 8vo, cloth [*Just Published.* **5/0**

"An excellent practical manual."—*Engineering.*

"An excellent work, giving the newest information."—*Horological Journal.*

ELECTROTYPING.

The Reproduction and Multiplication of Printing Surfaces and Works of Art by the Electro-Deposition of Metals. By J. W. URQUHART, C.E. Crown 8vo, cloth **5/0**

"The book is thoroughly practical; the reader is, therefore, conducted through the leading laws of electricity, then through the methods used by electrotypers, the apparatus, and the depositing processes, up to the final preparation of the work."—*Art Journal.*

GOLDSMITH'S HANDBOOK.

By GEORGE E. GEE, Jeweller, &c. Fifth Edition. 12mo, cloth . . **3/0**

"A good, sound educator, and will be generally accepted as an authority."—*Horological Journal.*

SILVERSMITH'S HANDBOOK.

By GEORGE E. GEE, Jeweller, &c. Third Edition, with numerous Illustrations. 12mo, cloth **3/0**

"The chief merit of the work is its practical character. . . . The workers in the trade will speedily discover its merits when they sit down to study it."—*English Mechanic.*

*** *The above two works together, strongly half-bound, price 7s.*

SHEET METAL WORKER'S INSTRUCTOR.

Comprising a Selection of Geometrical Problems and Practical Rules for Describing the Various Patterns Required by Zinc, Sheet-Iron, Copper, and Tin-Plate Workers. By REUBEN HENRY WARN. New Edition, Revised and greatly Enlarged by JOSEPH G. HORNER, A.M.I.M.E. Crown 8vo, 254 pp., with 430 Illustrations, cloth. [*Just Published.* **7/6**

BREAD & BISCUIT BAKER'S & SUGAR-BOILER'S ASSISTANT.

Including a large variety of Modern Recipes. With Remarks on the Art of Bread-making. By ROBERT WELLS. Third Edition. Crown 8vo, cloth **2/0**

"A large number of wrinkles for the ordinary cook, as well as the baker."—*Saturday Review.*

PASTRYCOOK & CONFECTIONER'S GUIDE.

For Hotels, Restaurants, and the Trade in general, adapted also for Family Use. By R. WELLS, Author of "The Bread and Biscuit Baker." Crown 8vo, cloth **2/0**

"We cannot speak too highly of this really excellent work. In these days of keen competition our readers cannot do better than purchase this book."—*Bakers' Times.*

ORNAMENTAL CONFECTIONERY.

A Guide for Bakers, Confectioners and Pastrycooks; including a variety of Modern Recipes, and Remarks on Decorative and Coloured Work. With 129 Original Designs. By ROBERT WELLS. Second Edition. Crown 8vo . **5/0**

"A valuable work, practical, and should be in the hands of every baker and confectioner. The illustrative designs are alone worth treble the amount charged for the whole work."—*Bakers' Times.*

THE MODERN FLOUR CONFECTIONER, WHOLESALE AND RETAIL.

Containing a large Collection of Recipes or Cheap Cakes, Biscuits, &c. With remarks on the Ingredients Used in their Manufacture. By ROBERT WELLS, Author of "The Bread and Biscuit Baker," &c. Crown 8vo, cloth . **2/0**

"The work is of a decidedly practical character, and in every recipe regard is had to economical working."—*North British Daily Mail.*

RUBBER HAND STAMPS

And the Manipulation of Rubber. A Practical Treatise on the Manufacture of Indiarubber Hand Stamps, Small Articles of Indiarubber, The Hektograph, Special Inks, Cements, and Allied Subjects. By T. O'CONOR SLOANE, A.M., Ph.D. With numerous Illustrations. Square 8vo, cloth . . . **5/0**

HANDYBOOKS FOR HANDICRAFTS.

BY PAUL N. HASLUCK.

Editor of "Work" (New Series), Author of "Lathe Work," "Milling Machines," &c.
Crown 8vo. 144 pp., price 1s. each.

These HANDYBOOKS *have been written to supply information for* WORKMEN, STUDENTS, *and* AMATEURS *in the several Handicrafts, on the actual* PRACTICE *of the* WORKSHOP, *and are intended to convey in plain language* TECHNICAL KNOWLEDGE *of the several* CRAFTS. *In describing the processes employed, and the manipulation of material, workshop terms are used; workshop practice is fully explained; and the text is freely illustrated with drawings of modern tools, appliances, and processes.*

THE METAL TURNER'S HANDYBOOK.

A Practical Manual for Workers at the Foot-Lathe. With over 100 Illustrations 1/0

"The book will be of service alike to the amateur and the artisan turner. It displays thorough knowledge of the subject."—*Scotsman.*

THE WOOD TURNER'S HANDYBOOK.

A Practical Manual for Workers at the Lathe. With over 100 Illustrations. 1/0

"We recommend the book to young turners and amateurs. A multitude of workmen have hitherto sought in vain for a manual of this special industry."—*Mechanical World.*

THE WATCH JOBBER'S HANDYBOOK.

A Practical Manual on Cleaning, Repairing, and Adjusting. With upwards of 100 Illustrations 1/0

"We strongly advise all young persons connected with the watch trade to acquire and study this inexpensive work."—*Clerkenwell Chronicle.*

THE PATTERN MAKER'S HANDYBOOK.

A Practical Manual on the Construction of Patterns for Founders. With upwards of 100 Illustrations 1/0

"A most valuable, if not indispensable manual for the pattern maker."—*Knowledge.*

THE MECHANIC'S WORKSHOP HANDYBOOK.

A Practical Manual on Mechanical Manipulation, embracing Information on various Handicraft Processes. With Useful Notes and Miscellaneous Memoranda. Comprising about 200 Subjects 1/0

"A very clever and useful book, which should be found in every workshop; and it should certainly find a place in all technical schools."—*Saturday Review.*

THE MODEL ENGINEER'S HANDYBOOK.

A Practical Manual on the Construction of Model Steam Engines. With upwards of 100 Illustrations 1/0

"Mr. Hasluck has produced a very good little book."—*Builder.*

THE CLOCK JOBBER'S HANDYBOOK.

A Practical Manual on Cleaning, Repairing, and Adjusting. With upwards of 100 Illustrations 1/0

"It is of inestimable service to those commencing the trade."—*Coventry Standard.*

THE CABINET MAKER'S HANDYBOOK.

A Practical Manual on the Tools, Materials, Appliances, and Processes employed in Cabinet Work. With upwards of 100 Illustrations . . 1/0

"Mr. Hasluck's thorough going little Handybook is amongst the most practical guides we have seen for beginners in cabinet work."—*Saturday Review.*

THE WOODWORKER'S HANDYBOOK OF MANUAL INSTRUCTION.

Embracing Information on the Tools, Materials, Appliances and Processes Employed in Woodworking. With 104 Illustrations. 1/0

OPINIONS OF THE PRESS.

"Written by a man who knows, not only how work ought to be done, but how to do it, and how to convey his knowledge to others."—*Engineering.*

"Mr. Hasluck writes admirably, and gives complete instructions."—*Engineer.*

"Mr. Hasluck combines the experience of a practical teacher with the manipulative skill and scientific knowledge of processes of the trained mechanician, and the manuals are marvels of what can be produced at a popular price."—*Schoolmaster.*

"Helpful to workmen of all ages and degrees of experience."—*Daily Chronicle.*

"Practical, sensible, and remarkably cheap."—*Journal of Education.*

"Concise, clear, and practical."—*Saturday Review.*

COMMERCE, COUNTING-HOUSE WORK, TABLES, &c.

LESSONS IN COMMERCE.

By Professor R. GAMBARO, of the Royal High Commercial School at Genoa. Edited and Revised by JAMES GAULT, Professor of Commerce and Commercial Law in King's College, London. Second Edition, Revised. Crown 8vo . **3/6**

"The publishers of this work have rendered considerable service to the cause of commercial education by the opportune production of this volume. . . . The work is peculiarly acceptable to English readers and an admirable addition to existing class books. In a phrase, we think the work attains its object in furnishing a brief account of those laws and customs of British trade with which the commercial man interested therein should be familiar."—*Chamber of Commerce Journal.*

"An invaluable guide in the hands of those who are preparing for a commercial career, and, in fact, the information it contains on matters of business should be impressed on every one."—*Counting House*

THE FOREIGN COMMERCIAL CORRESPONDENT.

Being Aids to Commercial Correspondence in Five Languages—English, French, German, Italian, and Spanish. By CONRAD E. BAKER. Second Edition. Crown 8vo, cloth **3/6**

"Whoever wishes to correspond in all the languages mentioned by Mr. Baker cannot do better than study this work, the materials of which are excellent and conveniently arranged They consist not of entire specimen letters, but—what are far more useful—short passages, sentences, or phrases expressing the same general idea in various forms."—*Athenæum*

"A careful examination has convinced us that it is unusually complete, well arranged and reliable. The book is a thoroughly good one."—*Schoolmaster.*

FACTORY ACCOUNTS: their PRINCIPLES & PRACTICE.

A Handbook for Accountants and Manufacturers, with Appendices on the Nomenclature of Machine Details; the Income Tax Acts; the Rating of Factories; Fire and Boiler Insurance; the Factory and Workshop Acts, &c., including also a Glossary of Terms and a large number of Specimen Rulings. By EMILE GARCKE and J. M. FELLS. Fourth Edition, Revised and Enlarged. Demy 8vo, 250 pp., strongly bound **6/0**

"A very interesting description of the requirements of Factory Accounts. . . . The principle of assimilating the Factory Accounts to the general commercial books is one which we thoroughly agree with. —*Accountants' Journal*

"Characterised by extreme thoroughness. There are few owners of factories who would not derive great benefit from the perusal of this most admirable work. —*Local Government Chronicle*

MODERN METROLOGY.

A Manual of the Metrical Units and Systems of the present Century. With an Appendix containing a proposed English System. By LOWIS D. A. JACKSON, A. M. Inst. C. E., Author of "Aid to Survey Practice," &c. Large crown 8vo, cloth **12/6**

"We recommend the work to all interested in the practical reform of our weights and measures."—*Nature.*

A SERIES OF METRIC TABLES.

In which the British Standard Measures and Weights are compared with those of the Metric System at present in Use on the Continent. By C. H. DOWLING, C.E. 8vo, strongly bound **10/6**

"Mr. Dowling's Tables are well put together as a ready reckoner for the conversion of one system into the other."—*Athenæum*

THE IRON AND METAL TRADES' COMPANION.

For Expeditiously Ascertaining the Value of any Goods bought or sold by Weight, from 1s. per cwt. to 112s. per cwt., and from one farthing per pound to one shilling per pound. By THOMAS DOWNIE. 396 pp., leather . . **9/0**

"A most useful set of tables, nothing like them before existed."—*Building News.*

"Although specially adapted to the iron and metal trades, the tables will be found useful in every other business in which merchandise is bought and sold by weight."—*Railway News.*

NUMBER, WEIGHT, AND FRACTIONAL CALCULATOR.

Containing upwards of 250,000 Separate Calculations, showing at a Glance the Value at 422 Different Rates, ranging from $\frac{1}{128}$th of a Penny to 20s. each, or per cwt., and £20 per ton, of any number of articles consecutively, from 1 to 470. Any number of cwts., qrs., and lbs., from 1 cwt. to 470 cwts. Any number of tons, cwts., qrs., and lbs., from 1 to 1,000 tons. By WILLIAM CHADWICK, Public Accountant. Third Edition, Revised. 8vo, strongly bound . **18/0**

"It is as easy of reference for any answer or any number of answers as a dictionary. For making up accounts or estimates the book must prove invaluable to all who have any considerable quantity of calculations involving price and measure in any combination to do."—*Engineer.*

"The most perfect work of the kind yet prepared."—*Glasgow Herald.*

THE WEIGHT CALCULATOR.

Being a Series of Tables upon a New and Comprehensive Plan, exhibiting at one Reference the exact Value of any Weight from 1 lb. to 15 tons, at 300 Progressive Rates, from 1*d.* to 168*s.* per cwt., and containing 186,000 Direct Answers, which, with their Combinations, consisting of a single addition (mostly to be performed at sight), will afford an aggregate of 10,266,000 Answers; the whole being calculated and designed to ensure correctness and promote despatch. By HENRY HARBEN, Accountant. Fifth Edition, carefully Corrected. Royal 8vo, strongly half-bound . . . . . **£1 5s.**

"A practical and useful work of reference for men of business generally."—*Ironmonger.*

"Of priceless value to business men. It is a necessary book in all mercantile offices."—*Sheffield Independent.*

THE DISCOUNT GUIDE.

Comprising several Series of Tables for the Use of Merchants, Manufacturers, Ironmongers, and Others, by which may be ascertained the Exact Profit arising from any mode of using Discounts, either in the Purchase or Sale of Goods, and the method of either Altering a Rate of Discount, or Advancing a Price, so as to produce, by one operation, a sum that will realise any required Profit after allowing one or more Discounts: to which are added Tables of Profit or Advance from $\frac{1}{4}$ to 90 per cent., Tables of Discount from $\frac{1}{4}$ to 98$\frac{3}{4}$ per cent., and Tables of Commission, &c., from $\frac{1}{8}$ to 10 per cent. By HENRY HARBEN, Accountant. New Edition, Corrected. Demy 8vo, half-bound . **£1 5s.**

"A book such as this can only be appreciated by business men, to whom the saving of time means saving of money. The work must prove of great value to merchants, manufacturers, and general traders."—*British Trade Journal.*

TABLES OF WAGES.

At 54, 52, 50 and 48 Hours per Week. Showing the Amounts of Wages from One quarter of an hour to Sixty-four hours, in each case at Rates of Wages advancing by One Shilling from 4*s.* to 55*s.* per week. By THOS. GARBUTT, Accountant. Square crown 8vo, half-bound **6/0**

IRON-PLATE WEIGHT TABLES.

For Iron Shipbuilders, Engineers, and Iron Merchants. Containing the Calculated Weights of upwards of 150,000 different sizes of Iron Plates from 1 foot by 6 in. by $\frac{1}{4}$ in. to 10 feet by 5 feet by 1 in. Worked out on the Basis of 40 lbs. to the square foot of Iron of 1 inch in thickness. By H. BURLINSON and W. H. SIMPSON. 4to, half-bound . . . . . **£1 5s.**

MATHEMATICAL TABLES (ACTUARIAL).

Comprising Commutation and Conversion Tables, Logarithms, Cologarithms, Antilogarithms and Reciprocals. By J. W. GORDON. Royal 8vo, mounted on canvas, in cloth case. [*Just Published.* **5/0**

AGRICULTURE, FARMING, GARDENING, &c.

THE COMPLETE GRAZIER AND FARMER'S AND CATTLE BREEDER'S ASSISTANT.

A Compendium of Husbandry. Originally Written by WILLIAM YOUATT, Fourteenth Edition, entirely Re-written, considerably Enlarged, and brought up to Present Requirements, by WILLIAM FREAM, LL.D., Assistant Commissioner, Royal Commission on Agriculture, 1893, Author of "The Elements of Agriculture," &c. Royal 8vo, 1,100 pp., with over 450 Illustrations, handsomely bound. [*Just Published.* **£1 11s. 6d.**

SUMMARY OF CONTENTS.

BOOK I. ON THE VARIETIES, BREEDING, REARING, FATTENING AND MANAGEMENT OF CATTLE.
BOOK II. ON THE ECONOMY AND MANAGEMENT OF THE DAIRY.
BOOK III. ON THE BREEDING, REARING, AND MANAGEMENT OF HORSES.
BOOK IV. ON THE BREEDING, REARING, AND FATTENING OF SHEEP.
BOOK V. ON THE BREEDING, REARING, AND FATTENING OF SWINE.
BOOK VI. ON THE DISEASES OF LIVE STOCK.
BOOK VII. ON THE BREEDING, REARING, AND MANAGEMENT OF POULTRY.
BOOK VIII. ON FARM OFFICES AND IMPLEMENTS OF HUSBANDRY.
BOOK IX. ON THE CULTURE AND MANAGEMENT OF GRASS LANDS.
BOOK X. ON THE CULTIVATION AND APPLICATION OF GRASSES, PULSE AND ROOTS.
BOOK XI. ON MANURES AND THEIR APPLICATION TO GRASS LAND AND CROPS.
BOOK XII. MONTHLY CALENDARS OF FARMWORK.

*** OPINIONS OF THE PRESS ON THE NEW EDITION.

"Dr. Fream is to be congratulated on the successful attempt he has made to give us a work which will at once become the standard classic of the farm practice of the country. We believe that it will be found that it has no compeer among the many works at present in existence. . . . The illustrations are admirable, while the frontispiece, which represents the well-known bull, New Year's Gift, owned by the Queen, is a work of art."—*The Times.*

"The book must be recognised as occupying the proud position of the most exhaustive work of reference in the English language on the subject with which it deals."—*Athenæum.*

"The most comprehensive guide to modern farm practice that exists in the English language to-day . . . . The book is one that ought to be on every farm and in the library of every land owner."—*Mark Lane Express.*

"In point of exhaustiveness and accuracy the work will certainly hold a pre-eminent and unique position among books dealing with scientific agricultural practice. It is, in fact, an agricultural library of itself."—*North British Agriculturist.*

"A compendium of authoritative and well-ordered knowledge on every conceivable branch of the work of the live stock farmer; probably without an equal in this or any other country."—*Yorkshire Post.*

FARM LIVE STOCK OF GREAT BRITAIN.

By ROBERT WALLACE, F.L.S., F.R.S.E., &c., Professor of Agriculture and Rural Economy in the University of Edinburgh. Third Edition, thoroughly Revised and considerably Enlarged. With over 120 Phototypes of Prize Stock. Demy 8vo, 384 pp., with 79 Plates and Maps, cloth. . . **12/6**

"A really complete work on the history, breeds, and management of the farm stock of Great Britain, and one which is likely to find its way to the shelves of every country gentleman's library."—*The Times.*

"The latest edition of 'Farm Live Stock of Great Britain' is a production to be proud of, and its issue not the least of the services which its author has rendered to agricultural science."—*Scottish Farmer.*

"The book is very attractive, . . . and we can scarcely imagine the existence of a farmer who would not like to have a copy of this beautiful and useful work."—*Mark Lane Express.*

NOTE-BOOK OF AGRICULTURAL FACTS & FIGURES FOR FARMERS AND FARM STUDENTS.

By PRIMROSE MCCONNELL, B.Sc., Fellow of the Highland and Agricultural Society, Author of "Elements of Farming." Sixth Edition, Re-written, Revised, and greatly Enlarged. Fcap. 8vo, 480 pp., leather. [*Just Published.* **6/0**

SUMMARY OF CONTENTS: SURVEYING AND LEVELLING.—WEIGHTS AND MEASURES.—MACHINERY AND BUILDINGS.—LABOUR.—OPERATIONS.—DRAINING.—EMBANKING.—GEOLOGICAL MEMORANDA.—SOILS.—MANURES.—CROPPING.—CROPS.—ROTATIONS.—WEEDS.—FEEDING.—DAIRYING.—LIVE STOCK.—HORSES.—CATTLE.—SHEEP.—PIGS.—POULTRY.—FORESTRY.—HORTICULTURE.—MISCELLANEOUS.

"No farmer, and certainly no agricultural student, ought to be without this *multum-in-parvo* manual of all subjects connected with the farm."—*North British Agriculturist.*

"This little pocket-book contains a large amount of useful information upon all kinds of agricultural subjects. Something of the kind has long been wanted."—*Mark Lane Express.*

"The amount of information it contains is most surprising; the arrangement of the matter is so methodical—although so compressed—as to be intelligible to everyone who takes a glance through its pages. They teem with information."—*Farm and Home.*

BRITISH DAIRYING.

A Handy Volume on the Work of the Dairy-Farm. "For the Use of Technical Instruction Classes, Students in Agricultural Colleges and the Working Dairy-Farmer. By Prof. J. P. SHELDON. With Illustrations. Second Edition, Revised. Crown 8vo. cloth. [*Just Published.* 2 6

"Confidently recommended as a useful text-book on dairy farming."—*Agricultural Gazette.*

"Probably the best half-crown manual on dairy work that has yet been produced."—*North British Agriculturist.*

"Of the shortest, little work we have yet seen on the subject."—*The Times.*

MILK, CHEESE, AND BUTTER.

A Practical Handbook on their Properties and the Processes of their Production. Including a Chapter on Cream and the Methods of its Separation from Milk. By JOHN OLIVER, late Principal of the Western Dairy Institute, Berkeley. With Coloured Plates and 200 Illustrations. Crown 8vo, cloth. 7 6

"An exhaustive and masterly production. It may be cordially recommended to all students and practitioners of dairy science."—*North British Agriculturist.*

"We recommend this very comprehensive and carefully-written book to dairy-farmers and students of dairying. It is a distinct acquisition to our library of the agriculture."—*Agricultural Gazette.*

SYSTEMATIC SMALL FARMING.

Or, The Lessons of My Farm. Being an Introduction to Modern Farm Practice for Small Farmers. By R. SCOTT BURN, Author of "Outlines of Modern Farming," &c. Crown 8vo, cloth. 3 6

"This is the completest book of its class we have seen, and one which every amateur farmer will read with pleasure, and accept as a guide."—*Field.*

OUTLINES OF MODERN FARMING.

By R. SCOTT BURN. Soils, Manures, and Crops—Farming and Farming Economy—Cattle, Sheep, and Horses—Management of Dairy, Pigs, and Poultry—Utilisation of Town-Sewage, Irrigation, &c. Sixth Edition. In One Vol., 1,250 pp., half-bound, profusely Illustrated 12 0

FARM ENGINEERING, The COMPLETE TEXT-BOOK of.

Comprising Draining and Embanking; Irrigation and Water Supply; Farm Roads, Fences and Gates; Farm Buildings; Barn Implements and Machines; Field Implements and Machines; Agricultural Surveying, &c. By Professor JOHN SCOTT. In One Vol., 1,150 pp., half-bound, with over 600 Illustrations. 12 0

"Written with great care, as well as with knowledge and ability. The author has done his work well; we have found him a very trustworthy guide wherever we have tested his statements. The volume will be of great value to agricultural students."—*Mark Lane Express.*

THE FIELDS OF GREAT BRITAIN.

A Text-Book of Agriculture. Adapted to the Syllabus of the Science and Art Department. For Elementary and Advanced Students. By HUGH CLEMENTS (Board of Trade). Second Edition, Revised, with Additions. 18mo, cloth 2 6

"It is a long time since we have seen a book which has pleased us more, or which contains such a vast and useful fund of knowledge."—*Educational Times.*

TABLES and MEMORANDA for FARMERS, GRAZIERS, AGRICULTURAL STUDENTS, SURVEYORS, LAND AGENTS, AUCTIONEERS, &c.

With a New System of Farm Book-keeping. By SIDNEY FRANCIS. Fourth Edition. 270 pp., waistcoat-pocket size, limp leather 1 6

"Weighing less than 1 oz., and occupying no more space than a match-box, it contains a mass of facts and calculations which has never before, in such handy form, been obtainable. Every operation on the farm is dealt with. The work may be relied on as thoroughly accurate, the whole of the tables having been revised by Dr. Fream. We cordially recommend it."—*North British Mail.*

THE ROTHAMSTED EXPERIMENTS AND THEIR PRACTICAL LESSONS FOR FARMERS.

Part I. Stock. Part II. Crops. By C. J. R. TIDY. Crown 8vo. cloth. [*Just Published.* 3 6

"We have no doubt that the book will be welcomed by a large class of farmers and others interested in agriculture."—*Standard.*

FERTILISERS AND FEEDING STUFFS.

A Handbook for the Practical Farmer. By BERNARD DYER, D.Sc. (Lond.) With the Text of the Fertilisers and Feeding Stuffs Act of 1893, &c. Third Edition, Revised. Crown 8vo, cloth. [*Just Published.* **1/0**

"This little book is precisely what it professes to be—'A Handbook for the Practical Farmer.' Dr. Dyer has done farmers good service in placing at their disposal so much useful information in so intelligible a form."—*The Times.*

BEES FOR PLEASURE AND PROFIT.

A Guide to the Manipulation of Bees, the Production of Honey, and the General Management of the Apiary. By G. GORDON SAMSON. With numerous Illustrations. Crown 8vo, cloth **1/0**

BOOK-KEEPING for FARMERS and ESTATE OWNERS.

A Practical Treatise, presenting, in Three Plans, a System adapted for all Classes of Farms. By JOHNSON M. WOODMAN, Chartered Accountant. Second Edition, Revised. Crown 8vo, cloth boards, **3/6**; or, cloth limp, **2/6**

"The volume is a capital study of a most important subject."—*Agricultural Gazette.*

WOODMAN'S YEARLY FARM ACCOUNT BOOK.

Giving Weekly Labour Account and Diary, and showing the Income and Expenditure under each Department of Crops, Live Stock, Dairy, &c., &c. With Valuation, Profit and Loss Account, and Balance Sheet at the End of the Year. By JOHNSON M. WOODMAN, Chartered Accountant. Second Edition. Folio, half-bound . . . . . *Net* **7/6**

"Contains every requisite form for keeping farm accounts readily and accurately."—*Agriculture.*

THE FORCING GARDEN.

Or, How to Grow Early Fruits, Flowers and Vegetables. With Plans and Estimates for Building Glasshouses, Pits and Frames. With Illustrations. By SAMUEL WOOD. Crown 8vo, cloth **3/6**

"A good book, containing a great deal of valuable teaching.—*Gardeners' Magazine.*

A PLAIN GUIDE TO GOOD GARDENING.

Or, How to Grow Vegetables, Fruits, and Flowers. By S. WOOD. Fourth Edition, with considerable Additions, and numerous Illustrations. Crown 8vo, cloth **3/6**

"A very good book, and one to be highly recommended as a practical guide. The practical directions are excellent."—*Athenæum.*

MULTUM-IN-PARVO GARDENING.

Or, How to Make One Acre of Land produce £620 a year, by the Cultivation of Fruits and Vegetables; also, How to Grow Flowers in Three Glass Houses, so as to realise £176 per annum clear Profit. By SAMUEL WOOD, Author of "Good Gardening," &c. Sixth Edition, Crown 8vo, sewed . . . **1/0**

"We are bound to recommend it as not only suited to the case of the amateur and gentleman's gardener, but to the market grower."—*Gardeners' Magazine.*

THE LADIES' MULTUM-IN-PARVO FLOWER GARDEN.

And Amateur's Complete Guide. By S. WOOD. Crown 8vo, cloth . **3/6**

"Full of shrewd hints and useful instructions, based on a lifetime of experience."—*Scotsman.*

POTATOES: HOW TO GROW AND SHOW THEM.

A Practical Guide to the Cultivation and General Treatment of the Potato. By J. PINK. Crown 8vo **2/0**

MARKET AND KITCHEN GARDENING.

By C. W. SHAW, late Editor of *Gardening Illustrated.* Cloth . . **3/6**

"The most valuable compendium of kitchen and market garden work published."—*Farmer.*

AUCTIONEERING, VALUING, LAND SURVEYING, ESTATE AGENCY, &c.

INWOOD'S TABLES FOR PURCHASING ESTATES AND FOR THE VALUATION OF PROPERTIES,

Including Advowsons, Assurance Policies, Copyholds, Deferred Annuities, Freeholds, Ground Rents, Immediate Annuities, Leaseholds, Life Interests, Mortgages, Perpetuities, Renewals of Leases, Reversions, Sinking Funds, &c., &c. 25th Edition, Revised and Extended by WILLIAM SCHOOLING, F.R.A.S., with Logarithms of Natural Numbers and THOMAS's Logarithmic Interest and Annuity Tables. 336 pp., Demy 8vo, cloth.

[*Just published.* *Net* 8/0

"Those interested in the purchase and sale of estates, and in the adjustment of compensation cases, as well as in transactions in annuities, life insurances, &c., will find the present edition of eminent service."—*Engineering*.

"This valuable book has been considerably enlarged and improved by the labours of Mr. Schooling, and is now very complete indeed."—*Accountant*.

"Altogether this edition will prove of extreme value to many classes of professional men in saving them many long and tedious calculations."—*Investors' Review*.

THE APPRAISER, AUCTIONEER, BROKER, HOUSE AND ESTATE AGENT AND VALUER'S POCKET ASSISTANT.

For the Valuation for Purchase, Sale, or Renewal of Leases, Annuities, and Reversions, and of Property generally; with Prices for Inventories, &c. By JOHN WHEELER, Valuer, &c. Sixth Edition, Re-written and greatly Extended by C. NORRIS, Surveyor, Valuer, &c. Royal 32mo, cloth 5/0

"A neat and concise book of reference, containing an admirable and clearly-arranged list of prices for inventories, and a very practical guide to determine the value of furniture, &c."—*Standard*.

"Contains a large quantity of varied and useful information as to the valuation for purchase, sale, or renewal of leases, annuities and reversions, and of property generally, with prices for inventories, and a guide to determine the value of interior fittings and other effects."—*Builder*.

AUCTIONEERS: THEIR DUTIES AND LIABILITIES.

A Manual of Instruction and Counsel for the Young Auctioneer. By ROBERT SQUIBBS, Auctioneer. Second Edition, Revised and partly Re-written. Demy 8vo, cloth 12/6

"The standard text-book on the topics of which it treats."—*Athenæum*.

"The work is one of general excellent character, and gives much information in a compendious and satisfactory form."—*Builder*.

"May be recommended as giving a great deal of information on the law relating to auctioneers, in a very readable form."—*Law Journal*.

"Auctioneers may be congratulated on having so pleasing a writer to minister to their special needs."—*Solicitors' Journal*.

THE AGRICULTURAL VALUER'S ASSISTANT.

A Practical Handbook on the Valuation of Landed Estates; including Rules and Data for Mensuring and Estimating the Contents, Weights and Values of Agricultural Produce and Timber, and the Values of Feeding Stuffs, Manures, and Labour; with Forms of Tenant-Right Valuations, Lists of Local Agricultural Customs, Scales of Compensation under the Agricultural Holdings Act, &c., &c. By TOM BRIGHT, Agricultural Surveyor. Second Edition, Enlarged. Crown 8vo, cloth 5/0

"Full of tables and examples in connection with the valuation of tenant-right estates, labour contents and weights of timber, and farm produce of all kinds."—*Agricultural Gazette*.

"An eminently practical handbook, full of practical tables and data of undoubted interest and value to surveyors and auctioneers in preparing valuations of all kinds."—*Farmer*.

POLE PLANTATIONS AND UNDERWOODS.

A Practical Handbook on Estimating the Cost of Forming, Renovating, Improving, and Grubbing Plantations and Underwoods, their Valuation for Purposes of Transfer, Rental, Sale or Assessment. By TOM BRIGHT. Crown 8vo, cloth 3/6

"To valuers, foresters and agents it will be a welcome aid."—*North British Agriculturist*.

"Well calculated to assist the valuer in the discharge of his duties, and of undoubted interest and use both to surveyors and auctioneers in preparing valuations of all kinds."—*Mark Lane Express*.

AGRICULTURAL SURVEYOR AND ESTATE AGENT'S HANDBOOK.

Of Practical Rules, Formulæ, Tables, and Data. A Comprehensive Manual for the Use of Surveyors, Agents, Landowners, and others interested in the Equipment, the Management, or the Valuation of Landed Estates. By TOM BRIGHT, Agricultural Surveyor and Valuer, Author of "The Agricultural Valuer's Assistant," &c. With Illustrations. Fcap 8vo, Leather

[Just Published. Net **7/6**

"An exceedingly useful book, the contents of which are admirably chosen. The classes for whom the work is intended will find it convenient to have this comprehensive handbook accessible for reference."—*Live Stock Journal.*

"It is singularly compact and well informed compendium of the facts and figures likely to be required in estate work, and is certain to prove of much service to those to whom it is addressed."—*Scotsman*

THE LAND VALUER'S BEST ASSISTANT.

Being Tables on a very much Improved Plan, for Calculating the Value of Estates. With Tables for reducing Scotch, Irish, and Provincial Customary Acres to Statute Measure, &c. By R. HUDSON, C.E. New Edition. Royal 32mo, leather, elastic hand **4/0**

"Of incalculable value to the country gentleman and professional man."—*Farmers Journal*

THE LAND IMPROVER'S POCKET-BOOK.

Comprising Formulæ, Tables, and Memoranda required in any Computation relating to the Permanent Improvement of Landed Property. By JOHN EWART, Surveyor. Second Edition, Revised. Royal 32mo, oblong, leather . **4/0**

"A compendious and handy little volume."—*Spectator.*

THE LAND VALUER'S COMPLETE POCKET-BOOK.

Being the above Two Works bound together. Leather **7/6**

HANDBOOK OF HOUSE PROPERTY.

A Popular and Practical Guide to the Purchase, Mortgage, Tenancy, and Compulsory Sale of Houses and Land, including Dilapidations and Fixtures: with Examples of all kinds of Valuations, Information on Building and on the right use of Decorative Art. By E. L. TARBUCK, Architect and Surveyor. Sixth Edition. 12mo, cloth **5/0**

"The advice is thoroughly practical."—*Law Journal.*

"For all who have dealings with house property, this is an indispensable guide."—*Decoration.*

"Carefully brought up to date, and much improved by the addition of a division on Fine Art. . . . A well-written and thoughtful work."—*Land Agent's Record.*

LAW AND MISCELLANEOUS.

MODERN JOURNALISM.

A Handbook of Instruction and Counsel for the Young Journalist. By JOHN B. MACKIE, Fellow of the Institute of Journalists. Crown 8vo, cloth **2/0**

"This invaluable guide to journalism is a work which all aspirants to a journalistic career will read with advantage."—*Journalist*

HANDBOOK FOR SOLICITORS AND ENGINEERS

Engaged in Promoting Private Acts of Parliament and Provisional Orders for the Authorisation of Railways, Tramways, Gas and Water Works, &c. By L. LIVINGSTONE MACASSEY, of the Middle Temple, Barrister-at-Law, M. Inst. C.E. 8vo, cloth . . . . . **£1 5s.**

PATENTS for INVENTIONS, HOW to PROCURE THEM.

Compiled for the Use of Inventors, Patentees and others. By G. G. M. HARDINGHAM, Assoc. Mem. Inst. C.E., &c. Demy 8vo, cloth . . **1/6**

CONCILIATION & ARBITRATION in LABOUR DISPUTES.

A Historical Sketch and Brief Statement of the Present Position of the Question at Home and Abroad. By J. S. JEANS, Author of "England's Supremacy," &c. Crown 8vo, 200 pp., cloth **2/6**

EVERY MAN'S OWN LAWYER.

A Handy Book of the Principles of Law and Equity. With a Concise Dictionary of Legal Terms. By A BARRISTER. Thirty-seventh Edition, carefully Revised, and including New Acts of Parliament of 1899. Comprising the *London Government Act, 1899; Sale of Food and Drugs Act, 1899; Infectious Diseases Notification Act, 1899; Small Dwellings Acquisition Act, 1899; Commons Act, 1899;* besides the *Benefices Act, 1898; Marriage Act, 1898. Inebriates Acts, 1898* and *1899; Criminal Evidence Act 1898; Vaccination Act, 1898, &c. Judicial Decisions during the year have also been duly noted.* Crown 8vo, 750 pp., strongly bound in cloth. *[Just Published.* **6/8**

*** *This Standard Work of Reference forms* A COMPLETE EPITOME OF THE LAWS OF ENGLAND, *comprising (amongst other matter):*

THE RIGHTS AND WRONGS OF INDIVIDUALS—LANDLORD AND TENANT—VENDORS AND PURCHASERS—LEASES AND MORTGAGES—PRINCIPAL AND AGENT—PARTNERSHIP AND COMPANIES—MASTERS, SERVANTS AND WORKMEN—CONTRACTS AND AGREEMENTS—BORROWERS, LENDERS AND SURETIES—SALE AND PURCHASE OF GOODS—CHEQUES, BILLS AND NOTES—BILLS OF SALE—BANKRUPTCY—RAILWAY AND SHIPPING LAW—LIFE, FIRE, AND MARINE INSURANCE—ACCIDENT AND FIDELITY INSURANCE—CRIMINAL LAW—PARLIAMENTARY ELECTIONS—COUNTY COUNCILS—DISTRICT COUNCILS—PARISH COUNCILS—MUNICIPAL CORPORATIONS—LIBEL AND SLANDER—PUBLIC HEALTH AND NUISANCES—COPYRIGHT, PATENTS, TRADE MARKS—HUSBAND AND WIFE—DIVORCE—INFANCY—CUSTODY OF CHILDREN—TRUSTEES AND EXECUTORS—CLERGY, CHURCHWARDENS, &C.—GAME LAWS AND SPORTING—INNKEEPERS—HORSES AND DOGS—TAXES AND DEATH DUTIES—FORMS OF AGREEMENTS, WILLS, CODICILS, NOTICES, &C.

☞ *The object of this work is to enable those who consult it to help themselves to the law, and thereby to dispense, as far as possible, with professional assistance and advice. There are many wrongs and grievances which persons submit to from time to time through not knowing how or where to apply for redress; and many persons have as great a dread of a lawyer's office as of a lion's den. With this book at hand it is believed that many a* SIX-AND-EIGHTPENCE *may be saved, many a wrong redressed, many a right reclaimed, many a law suit avoided; and many an evil abated. The work has established itself as the standard, legal adviser of all classes, and has also made a reputation for itself as a useful book of reference for lawyers residing at a distance from law libraries, who are glad to have at hand a work embodying recent decisions and enactments.*

OPINIONS OF THE PRESS.

"It is a complete code of English Law written in plain language, which all can understand. . . . Should be in the hands of every business man, and all who wish to abolish lawyers bills."—*Weekly Times.*

"A useful and concise epitome of the law, compiled with considerable care."—*Law Magazine.*

"A complete digest of the most useful facts which constitute English law."—*Globe.*

"This excellent handbook. . . . Admirably done, admirably arranged, and admirably cheap."—*Leeds Mercury.*

"A concise, cheap, and complete epitome of the English law. So plainly written that he who runs may read, and he who reads may understand."—*Figaro.*

"A dictionary of legal facts well put together. The book is a very useful one."—*Spectator.*

THE PAWNBROKER'S, FACTOR'S, AND MERCHANT'S GUIDE TO THE LAW OF LOANS AND PLEDGES.

With the Statutes and a Digest of Cases. By H. C. FOLKARD, Barrister-at-Law. Cloth **3/6**

LABOUR CONTRACTS.

A Popular Handbook on the Law of Contracts for Works and Services. By DAVID GIBBONS. Fourth Edition, with Appendix of Statutes by T. F. UTTLEY, Solicitor. Fcap. 8vo, cloth **3/6**

SUMMARY OF THE FACTORY AND WORKSHOP ACTS (1878-1891).

For the Use of Manufacturers and Managers. By EMILE GARCKE and J. M. FELLS. (Reprinted from "FACTORY ACCOUNTS.") Crown 8vo, sewed . . . . . **6D.**

BRADBURY, AGNEW, & CO. LD., PRINTERS, LONDON AND TONBRIDGE.